SCIENTIFIC AMERICAN
No. SUPPLEMENT 622

Scientific American Supplement, Vol. XXIV., No. 622. | NEW YORK, DECEMBER 3, 1887. | Scientific American Supplement, $5 a year.
Scientific American, established 1845. | | Scientific American and Supplement, $7 a year.

A DINING ROOM ELECTRIC RAILWAY.

ALTHOUGH lighting is, no doubt, the most important application of the distribution of electric energy, it is not the only one, and we wish no better example of this than the little railway established by Mr. Gaston Menier in his dining room. A car, passing and stopping in front of each guest, rapidly performs, under the direction of the master of the house, all the essential maneuvers of a punctual and well ordered service. The device consists of two essential parts—the track and the car. The track consists of four parallel rails, mounted upon oak stringers, placed end to end. The two external rails receive the wheels of the car, are insulated from each other, and communicate with the inductor of a dynamo-electric motor. The two internal rails upon which the contact rollers run put the electric source (a battery of twenty accumulators) in communication with the armature of the motor, through the intermedium of a commutator to the right of the master of the house. This commutator permits of stopping the train or of changing the direction of its running through a change in the direction of the current in the armature.

The oak stringers rest upon supports that raise the track about four inches above the level of the table, and in the space thus left are placed such table objects as salt cellars, covers, etc. Although the eight wheels that support the car form two bogies placed at its extremities, it would be difficult, since the length of the platform is thirty inches, to make the car describe a semicircle at the end of the table, as the radius of such a curve would be scarcely more than sixteen inches. This difficulty has been overcome by substituting an automatic switch for the curve. The track, starting from the pantry, where the dishes are placed upon the car, traverses a small tunnel and reaches the dining room. At the end of the table, the car meets a switch from which the track branches off to the right and left and passes before the guests sitting on each side. At the other end, the tracks unite again so as to form a single road.

The two switches are held in a given position by springs, and are set by the car itself. After the car has crossed the first switch, it runs from left to right till it reaches the opposite switch, and then runs back from right to left along the other side of the table.

It is unnecessary to say that the car can run in either direction on the same track, but, in order to make it pass from one track to the other, it must necessarily cross the switch to the right that is most distant from the pantry.

The gauge of the track is four and a half inches—a width sufficient to assure a satisfactory stability to the rolling stock without encumbering the table.

The car consists of a platform thirty inches in length by eight and a half in width that pivots upon two bogies, one of which carries the motor, while the other is but a two-axled truck, serving as a support. The dynamo-electric motor consists of a Siemens double T bobbin. The use of two bobbins, keyed at right angles, prevents dead points, and permits of starting the car from any position. The four wheels of the bogies are connected by coupling rods in order to increase the adhesion, and are actuated by a gearing that reduces their velocity in the ratio of 1 to 9. The expenditure of electric energy is insignificant, since the current does not exceed 0·5 or 0·6 ampere, with an electromotive force of 36 volts. The car weighs sixteen pounds when empty, and is capable of carrying one hundred and thirty pounds. By interposing resistances in the circuit, it is possible to vary the normal speed between four inches and three feet per second.

The stopping and starting are done very quickly, and a simple reversal of the current permits of sending the car from one point to another very speedily. It is wonderful to see how perfectly the car at once obeys the master's orders through the skillful maneuver of a commutator within his reach.—*La Nature.*

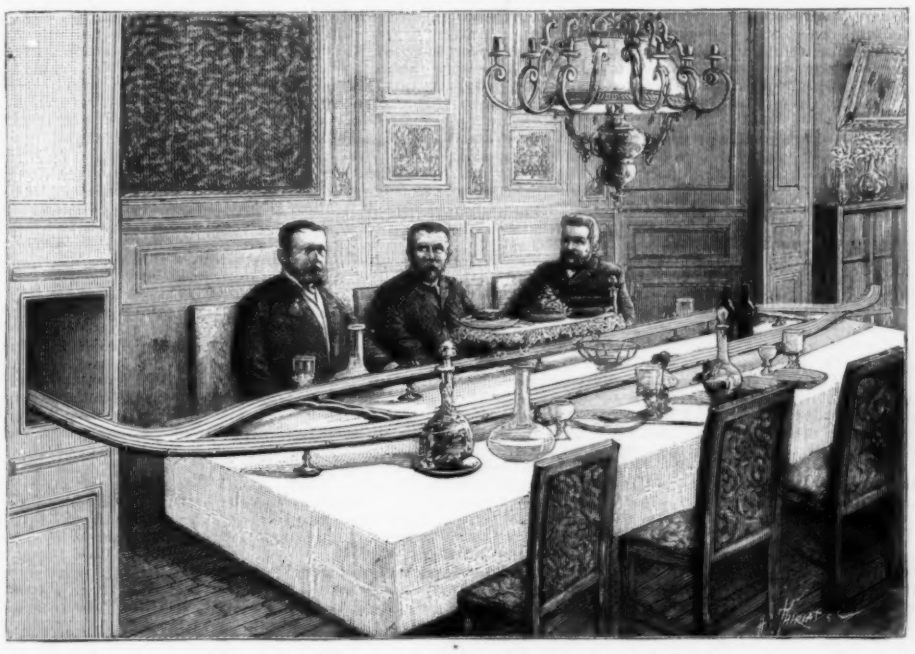


FIG. 1.—A DINING TABLE ELECTRIC RAILWAY.

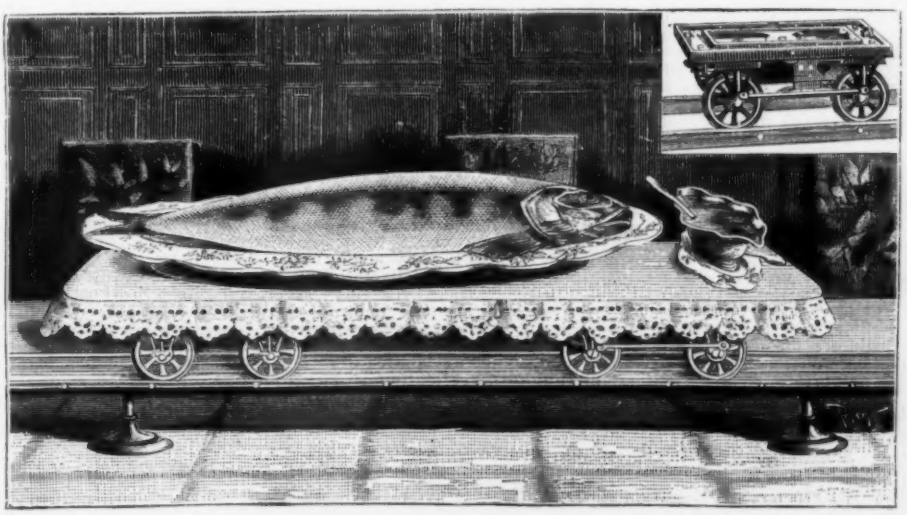


FIG. 2.—ELECTRIC CAR FOR DINING TABLE.

ELECTRICITY AS A MOTIVE POWER.*

By WM. WHARTON, JR.

SINCE the last annual meeting of this association the subject of using electricity as a substitute for horse power on street railways has received much attention, and great advances have been made in the practical application of it to that purpose, so that it may now be stated broadly there is no longer any doubt or uncertainty that electricity can be successfully and economically employed in a great many places, if not most places, as a substitute for animal power. Quite a number of electric railways are in operation in the United States, running satisfactorily under all the requirements of public service, so that there is much greater familiarity with and a more general knowledge of electricity among railroad men and the public than ever before. There is so much confidence in the practicability of electrical propulsion of cars being well established, that the subject is no longer treated with doubt or disdain; on the contrary, great interest and respectful attention are at once manifested whenever the subject is brought up.

Although some parties, interested perhaps in pushing forward their own special inventions, may claim too much, the actual facts as presented daily in the regular work of the cars are good enough to warrant this belief and confidence. Electricity, in its manifestations, applications, and capabilities, has been hitherto a subject the knowledge of which has been confined mainly to scientific circles, but it is evident that the time has come when it will be put in harness in place of the horse to draw cars and to perform many other duties which a few years ago would have been considered entirely chimerical and visionary. So long as the oxidation of metals or other chemical action was the only available method by which electricity could be produced, the expense attendant upon such means limited its use to a very narrow sphere. Since, however, steam power and water power have been so successfully employed to generate electricity, and to do it so cheaply, the range of its usefulness and application has been wonderfully enlarged from year to year. It is not intended in this paper to make use of scientific terms, or to discuss the question from any standpoint but that of practical observation and experience, nor is it intended that any comparisons shall be drawn between electric motors and steam locomotives, but there is a wide field for work in which neither the locomotive nor the horse is able to satisfactorily accomplish the duty called for.

The systems at present in use for electrical propulsion of cars are divided into two classes.

First, that in which the electricity is conducted from one or more active generating sources along a suitable conductor or conductors to be used in the cars, with proper return connections; and secondly, that system in which the electrical power is obtained from accumulators or secondary batteries carried along with or within the body of the car. Of the first there are several methods, namely: That in which the electricity is carried along a conductor above the ground, considerabiy above the car, either directly over it or toward one side.

That in which the electrical conductor is situated at the side of the railroad and elevated a few feet only above the ground.

That in which the electricity is carried upon the surface, either by a third rail or other conductor running on the level of the ground or pavement.

That in which the electricity is carried beneath the surface by a conductor placed within a suitable conduit for its protection, access being had to said conductor through a slot in the top of the conduit, so as to allow of electrical connection with the motor on the car.

The plans of having the conductor along the surface or at the side of the railroad not much above the surface have so many evident and practical disadvantages that they need not be taken into consideration in this paper. Therefore, the question is reduced to the three methods of overhead conduction, underground conduction, and storage batteries.

It is evident that better service must be furnished at the same cost, the same service furnished at a cheaper rate, or that both objects combined shall be attained by the use of electricity before it takes the place claimed for it. The writer believes fully that the last proposition of both better and cheaper service has already been proved by actual service and daily use, but in the nature of things improvements upon the present methods will be discovered, and "the survival of the fittest," which applies as well to mechanical appliances as to animated life, will by its inexorable laws weed out and discard those which are deficient or incompetent.

There are so many intelligent, persevering, and scientific minds engaged in active experiments and researches into the mysteries of nature's powers, and more especially those relating to electricity, that discoveries are constantly being made, human knowledge in this age extending more rapidly than at any previous time. The subject is fascinating and the prizes sought after are brilliant and valuable. The increased cheapness in production of

* A paper read before the Philadelphia Street Railway Convention, Oct. 19, 1887.

electricity which may fairly be assumed for the future will of course add to the advantages, and enlarge the scope, of its use. At present there are many places where electricity can be generated at a nominal cost by the use of water power, and this energy can be carried a number of miles without any loss or leakage of practical consequence.

Where this can be done, of course the parties have special advantages. So also there are many towns and cities in coal regions, or natural gas regions, where the same result of cheapness in productiou can be obtained, although by different means. As a case in point it may be mentioned that the electrical railway in Scranton, Pa., has its power station located about midway of the route, and immediately at the foot of a large hill or great mass of hundreds of thousands of tons of culm, which is principally composed of the small, fine particles of coal produced in mining or left after the screening and preparation of the commercial sizes of coal for the market. This has been accumulating for many years, is still accumulating, and has hitherto been considered only an inevitable nuisance, which the mining proprietors would gladly have given away for nothing to get rid of it, and not have it occupy their land.

The price which the railroad company pays for this culm is but ten cents per ton, and as it only has to be wheeled through the door of the engine house, the whole distance from the culm hill to the furnace under the boilers not being over fifty feet; and as the whole consumption per day is on the average but five tons, or in money value but fifty cents per day, it is evident that the cost of electricity in this case is exceedingly small indeed, that sum being sufficient for the fuel to produce the steam power which generates electricity enough to run four and sometimes five cars, carrying at times seventy-five passengers each over a railroad track about four and a half miles in length, having long grades, a number of which are five or six feet to the hundred, and the steepest of which is seven and a quarter feet per hundred. The tractive power required upon some of these grades is still further increased by curves or switches occurring on them. It may be well to mention some other points about this railroad in Scranton, which has been running about one year, with great success, and exhibits in many respects a favorable example of an electrical railway with overhead conductors. The cars have four wheels; two of them are open cars, each carrying one motor of 20 horse power. The motor is placed in the body of the car midway of its length, and all four of the wheels are driving wheels, the connections between the motor and the wheel axles being made by means of chains and sprocket wheels. Three of the cars are closed cars, each with one motor of 15 horse power, which is placed on a closed platform at the forward end of the car. In these the forward wheels only are driving wheels, and their connection with the motor is made in the same way as on the open cars, with chains and sprocket wheels. The company will shortly place four more cars upon the line, each with a motor of 25 horse power.

These larger cars are intended not only to propel themselves, but to be able each to haul in addition two other cars loaded with passengers up all the grades. The running time of the round trip on the main line, being in all eight miles, is one hour, which includes all stoppages and the waiting at each end of the route, so that the average speed attained is more than eight miles per hour. There is no difficulty in going much faster; in fact, the men in control of the cars have to be watched to prevent their running at excessively high speed, particularly on the return trip to the city, where the grades allow the car to be run for most of the distance by gravity alone. At the generating station there are two stationary engines of 180 horse power each, two dynamos of 100 horse power each, and four boilers of 100 horse power each. Only one engine and dynamo, however, and two of the boilers are in use at any one time. The railway company expects also to furnish in the future electricity for the lighting of the town of Dunmore, situated at one end of the line, by which the income of the company will be materially increased. The duplicate engine and dynamo and the duplicate set of two boilers are for the purpose of providing against contingencies of accident to those in use, and also to allow of alternations in service, thus giving opportunities of frequent examination and inspection.

Upon this railway, as before stated, the overhead system of conduction is employed, having flexible connection between the motor on the car and the carrier traversing the conductor, which is a solid copper wire of five-sixteenths inch diameter, suspended on a part of the route from transverse wires attached to wooden poles placed on both sides of the street about one hundred feet apart lineally, about twenty feet high and about six inches in diameter at the surface of the ground, and on the rest of the line suspended from arms projecting sideways from wooden poles at the side of the railway about twenty feet above the ground. The line is a single track railroad with several turnouts or passing places, at which points the electric overhead conductor branches off over the side track also; and an ingenious system is in use by which the carrier, running upon the overhead wire, with two grooved wheels of about two and a half inches diameter, automatically shifts the connections at the points of divergence from the main line, so that the carrier always follows that one of the overhead conductors which is above the track upon which the car is traveling.

It is contemplated, however, to use two separate and independent overhead conducting wires throughout the whole length of the route, so as to avoid the possibility of any difficulty with the carriers at the points of intersection at the turnouts, although this has not happened often. The return current of electricity is taken by the rails. The electrical current has a tension of about six hundred volts, which, while sufficient to give a shock, could not produce any dangerous effect on man in case the current should by any means be diverted. Part of the road is laid with tram rails and the rest with T rails, and a part is paved and the rest unpaved, so that these different conditions, in connection with the many grades and the curves and the turnouts, give ample opportunity to thoroughly test the working of the system. Although the overhead wires in this case do not present any more unsightly appearance than the numerous telegraph cables and wires to which we are so accustomed, it is, however, evident that the use of the overhead system will be prohibited in most cities and towns, especially since the general determination to place all electrical wires through cities underground. The noise of the carriers running on the conductors is not much, although it can be readily noticed; but the noise produced by the motors and the chain and sprocket connections is quite considerable. This latter could be entirely avoided by the use of a noiseless motor and a better method of connection, of which motors and connections there are several kinds easily obtainable. Noiseless, efficient, and durable electric motors suitable for use on cars can be had in which the weight per horse power does not exceed sixty pounds.

In a paper of the length to which this must necessarily be limited, it will be impossible to do much more than treat of the subject in a general manner, but it can be stated specifically and certainly that electric railways with overhead conduction have demonstrated beyond a doubt their capability to propel a few cars, even if heavily loaded, at less cost and much greater speed than could be obtainable on railways operated by horse power. This is true in places where the coal required must be bought at usual rates and the exceptional advantage of fuel at merely nominal cost does not exist, as at Scranton, and likewise at Wilkesbarre, where an electrical railway is under construction, upon which the cost of coal used will not exceed sixty or seventy cents per day for five cars.

In the case of electrical railways with underground conduction the effort has been made to give all the advantages of the overhead system and at the same time remove the objection which in most places is absolutely prohibitive of having the conductors and poles or other supports obstructing the streets. In doing this, however, great difficulties arise, some of them of a very serious character. The costly conduit, with the needful arrangements for drainage and for cleaning out, together with the increased care necessary to provide against the considerable loss or leakage of electricity, which nevertheless generally takes place in spite of all precautions, detract greatly from the apparent advantages of the plan. Many inventions have been patented and numberless devices contrived to overcome the many objections of this method, but there is great room for doubt whether practical success has yet been obtained.

Neither by overhead nor underground conduction have more than a few cars as yet been moved simultaneously upon railways, although many ingenious arrangements are offered by various parties who confidently assert they can run any required number of cars. This, however, yet remains to be proved. Both plans, also, are open to another serious objection in the entire stoppage of travel on the whole line in the case of breakage or derangement of any part of the conducting apparatus or the generating machinery. In this respect they are under the same disability that the cable system of car traction is hampered with. Possibly, by suitable arrangements of duplicate engines, boilers and dynamos, duplicate conductors, and auxiliary, sectional, or relay systems of conduction, this disability, threatening as it appears to be, may be so reduced as to be of no great detriment. This, however, also remains to be demonstrated.

Taken altogether, underground conduction does not compare favorably with overhead conduction up to this time. One great trouble with the latter plan, however, is that although it can be used to great advantage and economy on lines running a few cars in towns, or in suburban districts outlying large cities, it will probably never be allowed by the municipal authorities in large cities, which of course are the very places where the advantages of electrical propulsion are needed the most. To move a large number of cars, as for instance upon the Third avenue or Broadway lines in New York City, the electrical conductor, whether overhead or underground, must be of great size if the current is of low tension; while on the other hand, if a small or moderate sized conductor be used, the current must then be of dangerously high tension, and of course it would then be very difficult to avoid great loss of electricity from leakage.

There remains to be considered the accumulator or secondary battery system. In this each car carries its own supply of energy, and is entirely independent of any method of continuous electrical conduction. No change of track or roadway is required, nor any costly conduit or unsightly poles or other supports, while the cars can run anywhere that a car can be taken by horses. These points are of immense advantage, and are the chief merits advanced by its advocates, independent of its economy over horse power.

In practice, cars of the size of the usual two-horse cars are provided with about 80 accumulators, weighing when filled with fluid and ready for use about 40 pounds each. These cells are placed under the seats, one half being on each side of the car. Their combined weight is 3,200 pounds, and the weight of two motors each of five horse power should not, together with their connections to the car axles, exceed 800 pounds, so that the additional weight imposed upon the car is say 4,200 pounds, which allows 200 pounds for the apparatus to control the current and for other electrical appliances. This added weight, if placed upon a four-wheel car, may be of disadvantage to the car or to the track. If this should be the case, the difficulty is removed by the use of eight wheels on two swinging trucks, which support the car much better, and distribute the weight upon the track. Both these kinds of storage battery cars are in service with entire success. The charging of the cells is done by a dynamo driven by steam power or any other desirable means, and it takes four hours to charge cells which are able to perform four hours' work. To remove from the car the cells which have done their work and to replace them by freshly charged cells takes no more time than the time required to change horses. It requires 10 horse power exerted for four hours to charge the batteries or cells of each car, so that 40 horse power hours are needed to accomplish it.

The cost of running large stationary steam engines of, say, 200 to 400 horse power, constructed with the modern improved cut-off appliances and other economical devices, has been found, after extensive investigations, not to exceed two-thirds of one cent per horse power hour.

This allowance is a liberal one, and is above, rather than below, the actual average cost, including fuel at average market prices, attendance, repairs to engine and boilers, oil, etc. We will, however, take it at 1 cent per horse power hour. Forty horse power hours at 1 cent costs 40 cents, which is the cost of 4 hours' car service; and as the day's work of a car should be taken as 16 hours, we have as the whole cost of a day's supply of electricity four times 40 cents, or $1.60.

Since four teams of two horses are required to draw a car for 16 hours, and as one additional horse per car is the usual allowance for sick or disabled horses, nine horses per car are needed for a day's work, which, at 50 cents per horse for feed, bedding, attendance, shoeing, etc., is $4.50, against $1.60 for the storage battery electricity. Making extraordinary allowance for possible errors in this comparison, the difference is still astonishing to those who have not looked into the matter critically. With motors properly constructed, a speed of eight or nine miles per hour is readily accomplished—in fact, eight miles per hour may be taken as the speed at which such motors will work to the best advantage, and return the greatest percentage of mechanical efficiency. The requirements of street car service demand variable rates of speed, as for instance in crowded streets, behind other vehicles, or in turning curves and entering switches it is necessary to go slowly and cautiously; and the weight of the load carried at different times will vary from an almost empty car to one overloaded. These conditions, together with increased power needed to ascend grades and to start loaded cars, especially on up grades, call for electric motors which will under such greatly varying circumstances respond at all times almost equally well.

There are motors which while engaged in performing an equable work and running at an equable speed, for both of which purposes the motor was specially made, will return 90 or possibly 95 per cent. of efficiency, while the same motor when run at some different speed or under some different load may return but 30 or 35 per cent. So that the average performance of such motors in street car service would probably give only 50 per cent. return of efficiency. Motors can, however, be obtained which will under all the variations of street car work constantly return 75 per cent. of efficiency.

The durability of storage batteries is a point which those interested in other systems are very prone to doubt, but it has been proved in actual use in cars that they will continue in good, serviceable condition for eighteen months or two years. Makers of these batteries offer to guarantee them good for two years of street car service. The lead-lined wooden containing boxes will last for many years. The negative plates are good for more than two years, while the positive plates are certainly good for eighteen months, if not more.

The plates being of lead and lead oxide are still of value when they become unserviceable, for the metal can be recast into new plates, and the lead can be recovered from the oxide. The first cost of storage battery cars and the engine and dynamos is at present prices considerably more than the first cost of cars provided with suitable complement of horses and harness; but when the saving in first cost obtained by dispensing with the ground and the stables required for horses is taken into account, the balance will in many cases be in favor of storage battery cars. This is of course applicable more particularly to large cities where ground is very valuable. By methods now being introduced into the manufacture of storage batteries, their production will shortly be made at a reduced cost, and their durability increased at the same time.

It should be remembered that the increased speed at which electric cars can travel is so much greater than horses could draw them that two cars can readily do the work of three horse cars, especially as the electric cars requires no time for resting at the ends of the route; but although they can easily do this, so much increase of speed would not be allowed or be practicable through the streets of most cities or towns. It could be done with safety and advantage through wide streets or avenues and in suburban districts. It will, however, be perfectly safe to say that three electric cars can do the work of four horse cars, and, if desired, they can at the same time be of greater capacity than horse cars, for while the horses can do no more, no such difficulty exists with electricity. Without referring to the excessive first cost required for the expensive cable traction system, and comparing the first cost of the entire plant and equipment needed for a storage battery electric railway on which three cars will perform the service of four horse cars with the first cost of the entire plant and equipment of a railway using horse power, it will be found that the advantage will in most cases be in favor of storage electricity. Let us now compare the operating expenses.

Running expenses of four two-horse cars for one year, to wit:

Conductors, 365 days at $3.00 each car per day of 16 hours	$4,380
Drivers " " 2.50 " " " " "	3,650
36 horses, " " .50 " per day	6,570
	$14,600
One year's deterioration and repair of four cars at $200 each	800
" " " of 36 horses at $40 each	1,440
	$16,840

Running expenses of three storage battery cars for one year, to wit:

Conductors, 365 days at $3.00 each car per day of 16 hours	$3,285.00
Drivers, " " 2.50 " " " " "	2,737.50
Electricity, " " 2.00 " " " " "	2,190.00
	$8,212.50
One year's deterioration and repair of three cars, including dynamos, storage batteries, and motors, $1,600 each	4,800.00
	$13,012.50

This leaves a balance to the credit of the storage battery cars of $3,827.50.

The fact of each storage battery car carrying within itself its own energy gives to the individual cars an independence of action which neither the cable traction plan nor the overhead or underground system of electrical propulsion possesses, for all of these depend upon central sources of power, which may at any time be interrupted, so that breakage or accident to any part involves the stoppage of the whole line.

In a sanitary and cleanly point of view, the withdrawal of the car horses from our streets would be of great benefit, and this would be accomplished without having, as in the case of the cable railway, an open drain, which, although supposed to be kept clean, in fact nearly always contains a deposit of street refuse to a greater or less extent.

The leakage of electricity in storage batteries, charged but not in use, need not be taken into account for

any length of time that cars would probably stand idle. In fact, the leakage from batteries in good condition would not exceed ten per cent. in three months.

The percentage of mechanical energy given by the steam engine which is recovered in actual work under the variable conditions of street car service on the driving axles, with storage battery cars properly equipped, is at least forty per cent., and with electricity by direct conduction at least fifty per cent. In cable traction, after deducting the power needed to move the cable and to revolve the wheels guiding and carrying the cable, not over twenty-five per cent. is left for drawing the cars, and on some cable railways even less.

The increased speed so easily and advantageously obtained on electric railways as a class not only enables three cars to do the work of at least four horse cars, and effect the great annual saving shown above, but it has a tendency to invite travel and thereby increase receipts, also to give street railways the opportunity to extend their lines advantageously further into outlying districts and to compete on better terms with elevated roads and steam railroads than would be possible with horse power.

The rapid deterioration and destruction of street car horses shows the exacting and terrible nature of their work, although it is for only four hours per day. Their powers are already overtaxed, and they can do nothing more either in speed or in load carried.

Electric cars, by dispensing with horses, allow more room in the streets for other vehicles, and this advantage in crowded streets is of moment. Take, for instance, Washington Street, Boston, or Broadway, New York, and it will be readily seen that this relief to the clogged traffic would be great.

Electric cars can go backward or forward with equal facility, they are under perfect control, can stop and start more quickly than horse cars, and in case of delay can make up lost time. They never get sick with epizooty or other disease, and during strikes or other periods of enforced idleness do not require to be fed. On down grades they will run by gravity without the expenditure of other force, and on level or nearly level stretches a very little electric energy continues their motion when once they are started.

The electricity, besides running the motors, will supply the car with incandescent electric lights, actuate an electric signal gong, and operate electric bells for the use of the conductor and passengers in stopping or starting the car. It is usual to have the regular hand brake for stopping the cars, but the motors can be instantly reversed by electricity if desired. This method, however, should only be employed when it is necessary to stop the car very quickly to avoid accident or for some other imperative reason. By this means the car can be stopped in much less distance than is possible by the hand brake, which, of course, operates with the same efficiency whether upon electric cars or horse cars.

It has been questioned whether in winter, when the tracks are liable to be obstructed with snow or ice, the electric cars will be able to propel themselves, owing to the fact that they obtain their power of propulsion from the adhesion of the wheels upon the rails, so that if the wheels are prevented from reaching the track there would be a great liability of their slipping and turning around without giving any forward motion to the car itself. In answer to this, it may be stated that during last winter on the electric railway in Scranton, having the overhead conduction system, and from experiments made in Philadelphia with a storage battery car, it was found that there was no unusual difficulty presented in snow storms, the wheels, owing to the added weight, settling more readily through the snow, and thus reaching the rails. Upon roads properly equipped with snow plows, or snow sweepers with revolving brushes, propelled by powerful electric motors, the clearing of snow from the tracks would no doubt be much more efficient than horse power could effect. Street car electric motors of fifty horse power or more, if required, can be as easily made, and are as easily controlled, as motors of five or ten horse power, so that electricity has ample ability to keep the tracks clear from accumulations of snow. As with locomotives, sand boxes should be placed upon electric cars, so that if any slipping of the wheels should be observed, either from the greasy, slippery condition of the track, sometimes seen in damp weather when the streets are not properly cleaned, or from snow or ice upon the track, the driver, by opening a suitable valve, can let out a little sand upon the rail, and at once overcome the difficulty.

It is sometimes asked why two motors of five horse power each should be needed upon a car usually drawn by two horses. In explanation of this it may be stated that a car horse can, and very often does, exert for a short time in starting a car or upon steep grades a force of five or even more horse power. A mechanical horse power is the measure of the moderate duty which a horse can constantly and regularly exert day after day in a regular day's work without injury; but car horses are constantly temporarily called upon to exert unusual and unreasonable power, which is the reason they are so rapidly destroyed in street car service. It is evident therefore that the electric motors must be able, when called upon, to exert the same power that the horses under pressure can be made to perform temporarily, so that a maximum of five horse power in each of the two motors will develop only such force as the requirements of street car service are constantly demanding during short periods of time.

It is not intended in this report to indicate that cable railways for use on steep hills or high grades will be superseded by electric railways, for the latter are limited to such grades as the adhesion of their wheels upon the rails will enable them to surmount, just as in the case of the steam locomotive, so that there is a suitable and proper sphere of usefulness for cable railways in the many places for which they are particularly adapted.

It has been proposed to increase the tractive power of electric cars upon inclines by causing magnetic attraction to be developed between the wheels and the rails, and also by the use of other devices. All these methods present complications which probably will more than outweigh the advantages sought to be attained.

In developing the best construction and management of electric cars and railways, careful attention to details, some of which at first sight may appear trivial, should be exercised, in order to obtain the best results, no matter which of the three plans be adopted. It should, however, be said that in practice at the present time the running of electric cars requires no more intelligence or skill than the running of horse cars, and also that the electric current with continuous conduction on lines using a few cars need not be of such tension as to endanger human life, 500 volts being sufficient. With the storage battery system the tension of the current is so low, 160 volts being sufficient, that no shock whatever could be experienced by a man taking through his body the whole current required to propel the car. This has been repeatedly done, some of the people stating they felt nothing at all, and the others no more that a slight tingling sensation.

The term "storage batteries," so generally in use, is apt to give a wrong impression, no electricity whatever being stored or contained within them, for in charging the batteries a chemical action is forced to take place, and when this chemical action is allowed to reverse itself, electricity is generated thereby. The car motor immediately uses this, and when the motor is stopped the chemical action and, therefore, the generation of electricity cease.

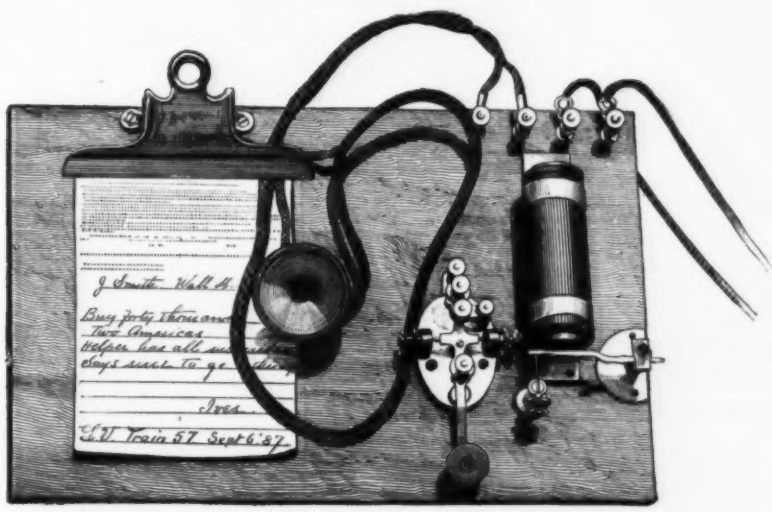
In this report care has been taken not to refer by name to any patented inventions or to recommend any particular make of electrical appliances. As to these matters, those proposing to use electricity, whether by overhead or underground conduction or by storage batteries, should of course be careful to select such methods as are the most reliable, efficient and durable, and to deal with parties not only responsible as to the validity of their patents, but capable of doing what they undertake to perform.

Any one who peruses the railway journals and notices the number of electric railways now in operation, and the still greater number of those in course of actual construction or projected, has cause for surprise, if he has not closely been following the course of events.

That electricity, by some of the present methods of its use, or by better ones yet to be invented, will entirely supersede the use of horses and cable traction upon all street railways, excepting under the special conditions for which cable traction is occasionally applicable, is a question that admits of very little doubt.

TRAIN OPERATOR'S EQUIPMENT, WITH BATTERY.

SENDING AND RECEIVING MESSAGES.



SENDING AND RECEIVING INSTRUMENTS.

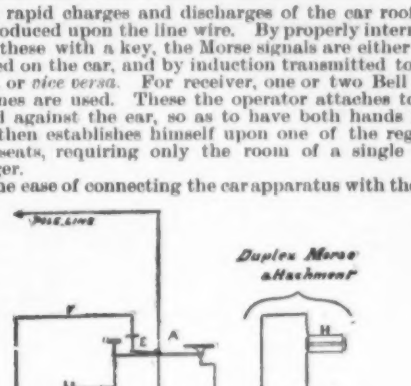
TELEGRAPHING TO AND FROM TRAINS IN MOTION.

THIS new system of telegraphy, by which messages may be sent from and received on the cars when in motion, is now in regular operation on the Lehigh Valley Railway. An interesting exhibition of the system was given by the Consolidated Railway Telegraph Company, of this city, on the 6th of October. A special train of six cars was run from Jersey City to Easton, carrying the apparatus for transmitting and receiving. The train contained the guests of the Consolidated Company, and the party was the outcome of an invitation extended by Mr. Charles A. Cheever, the president of the company, to the New York Electric Club. The trip occupied about five hours. During the running of the train, the operator was kept busy sending and receiving messages. Although the speed of the train has no relation to the practical working of the apparatus, yet a greater measure of public appreciation may be looked for from the fact that the cars ran at very high speed, exceeding sometimes sixty miles an hour.

The method is a simplification in some respects of the Edison system, already very fully described by us. The tin roofs of the cars are utilized as one leaf of a condenser that is charged and discharged by the action of a "buzzer" many hundred times a second. The other leaf of a condenser is represented by a line of wire strung on low poles carried along the track as nearly as possible at an even distance from the track.

The rapid charges and discharges of the car roof are reproduced upon the line wire. By properly interrupting these with a key, the Morse signals are either produced on the car, and by induction transmitted to the line, or *vice versa*. For receiver, one or two Bell telephones are used. These the operator attaches to his head against the ear, so as to have both hands free. He then establishes himself upon one of the regular car seats, requiring only the room of a single passenger.

The ease of connecting the car apparatus with the car



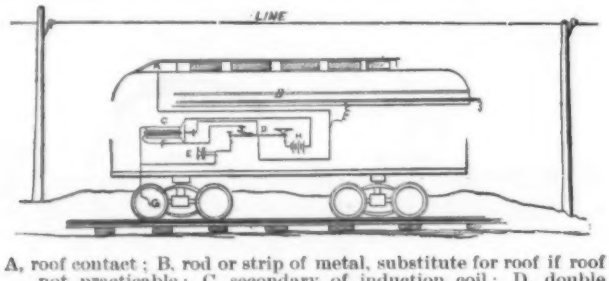
A, double pointed key; B, induction coil; C, battery; D, primary circuit; E, extra contact key; F, secondary circuit; G, telephone and circuit; H, electro-magnets; I, Morse apparatus; J, earth connection; K, condenser.

ARRANGEMENT OF APPARATUS AT TERMINAL STATION.

is noticeable. By spring clips proper connections are rapidly made by the operator upon being assigned to any particular car.

A clip is sprung upon the car truck to secure ground. From this a wire leads to the instruments. From them another wire is carried to the roof of the car, where it is also secured by a spring clip. Two or more car roofs are thus connected to obtain increased surface. The car connections are the acme of simplicity.

The apparatus consists of the "buzzer," transmitting key, and induction coil. The core of the latter is the magnet of the "buzzer." These are secured to a small lap board. For battery, twelve chromic acid cells (Bunsen type) are used. A compact form of these has been adopted, and is carried in a hand



A, roof contact; B, rod or strip of metal, substitute for roof if roof not practicable; C, secondary of induction coil; D, double pointed key with extra contact; E, telephone receiver; F, primary circuit; G, ground contact on box; H, battery.

CAR EQUIPMENT.

case. The whole equipment for a car is carried by one man, the operator himself, and can be attached and put in working order and transmit messages or receive them in a few minutes.

DESCRIPTION OF THE NEW TAY VIADUCT.*

By Mr. F. F. S. KELSEY, M. Inst. C. E., Resident Engineer.

THE new viaduct across the Tay, near Dundee, which has once more established direct railway communication between the counties of Fife and Forfar after an interval of nearly eight years, is situated throughout the extent of the straight portion, or four-fifths of its total length, at a distance of 60 ft. center to center from the old structure. At the north end of the strait a curve of 21 chains radius gradually reduces the distance between them, until they join in a common center line at the point where they cross the esplanade at Dundee. Unlike the old viaduct, the new one carries a double line of railway, and consequently gains enormously in stability from the greatly increased width of the piers. The chief dimensions of the new work are as follows:

	Feet.
South end of Wormit arching to high girders....	3585
High girders.....	3156
North end of high girders to north end of viaduct	3786
Total length=33 ft. short of 2 miles=	10,527

	Ft.	In.
Width between parapets.....	25	6
Maximum width of piers at base.....	55	0
Minimum " "	36	0
Maximum headway above high water.....	77	0
Maximum height of rails above high water....	83	0
Minimum " " " "	25	0
Maximum height of piers from foundations to top	141	6

There are in all eighty-six spans, five of which consist of brick arches, and the remainder of girder work. Of the brick arches, four of 50 ft. span are situated at the southern end of the viaduct, and one of 25½ ft. at the northern end. Seventy-three of the piers have cylinder bases, and may be divided into two groups, forty-nine being constructed with wrought iron cylinder bases and twenty-four with cast iron. The former are in the straight and the latter in the curved portion of the viaduct. The portion of the pier below low water consists of two such cylinders, which, in the case of the piers for the thirteen large spans in the center of the river, are placed at a distance from each other of 32 ft., and in the rest of the piers 26 ft., center to center. Except in the case of those for piers Nos. 5-14, the cylinders are all splayed at the base, and have a base diameter varying from 10 ft. up to 23 ft. The 10 ft. cylinders, which form the bases of twenty-four of the piers in the curve, are of cast iron, all above this size being of wrought iron, and made of such a length that when sunk to the required depths the tops might project slightly above low water level. They are all lined with brickwork filled in with concrete. From low water up to high water level the piers in the first group consist of two circular blue brick shafts of 12 in. less diameter than the cylinders. They are filled in with concrete, and joined together at high water level by means of a strong connecting piece, which also consists of blue brickwork filled in with concrete, the portion between the shafts resting on cast iron girders. In the cast iron cylinder piers the cylinders are continued up to the connecting piece, and cast iron segments of cylinders and plates take the place of the blue brickwork in the connecting piece itself. On the top of the brickwork, and forming part of the connection, a wrought iron framework made chiefly of channel irons is placed, and securely attached to the shafts below by means of sixteen holding-down bolts of 2½ in. diam. and 2 ft. length, which are embedded in the masonry. This framework forms the base for the upper portion or superstructure of pier, which is riveted to it. In the case of piers Nos. 5-64, the superstructure consists of two wrought iron octagonal shafts, joined together near the top in the form of an arch, and is composed of plates connected at the angles by means of two splayed channel irons on the outside and an obtuse angle iron on the inside. Outside and inside T irons cover the other vertical joints, and serve to stiffen the structure, which is further strengthened by means of bracings and horizontal diaphragms placed at intervals inside the shafts. Short cross girders near the top support the cast iron bed plates for the main girders. The height of these pier superstructures varies from 20 ft. to 68 ft. In piers Nos. 65-77 the superstructure and connecting piece are combined, on account of the reduced height of the piers, and assume the form of a tapered box, stiffened with channels and tees in the same way as the rest of the piers.

In sinking the cylinders down to their several depths below the bed of the river, pontoons specially designed for the purpose were used. They were constructed with two apertures of sufficient size to admit of the pair of cylinders passing through at their proper distance from each other; and were also provided with four cylindrical legs, capable of being lowered down to the bed of the river or lifted off it by hydraulic power. During the greater part of the time that cylinder sinking was going on, four of these pontoons were employed, the dimensions of the largest being 80 ft. by 67 ft. by 7 ft. deep. The work of cylinder sinking was carried out as follows: A pontoon having been floated into position and its four legs lowered down to the bed of the river, the two cylinders for the pier were suspended in the apertures, and after having been lined with brickwork, were gradually lowered down to the bed of the river by means of hydraulic jacks. The excavation for the cylinders was then proceeded with by means of a subaqueous digger worked by a crane on the pontoon. Owing to the nature of the strata through which the cylinders passed, it was necessary to weight them in order to force them down as the excavation proceeded. In some cases as much as 400 tons were placed upon the cylinder for this purpose. Where silty sand was met with, the use of a centrifugal pump was found to be of great assistance. The continual pumping of the water from inside the cylinder caused the sand beneath the cutting edge to be scoured toward the center of the cylinder, where it could be more readily got at by the digger. When sunk to their required depths, the cylinders were filled with concrete, and the pontoon was then floated away to the next pier. The depths of the foundations vary from 6 ft. to 38½ ft. below the river bed, as the average for the pair of cylinders. The shallowest foundations are at piers 7 and 8, where the cylinders rest on red sandstone; and the deepest at pier 20, which is founded on sandy clay. Thirty-three of the piers, including those for the thirteen large spans, rest on sand foundations, and the average depth to which these cylinders are sunk below the river bed is 26½ ft. The work of sinking the seventy-three pairs of cylinders occupied nearly three years and a half, having been commenced on 1st February, 1883, and completed on 20th July, 1886. All the foundations of the cylinder piers have been subjected to a weight 33 per cent. heavier than that which they will be required to carry. The test load, consisting of iron blocks weighing ½ ton each, was applied at the level of the tops of the cylinders before building the blue brick shafts upon them. The load on the pair of cylinders varied from 608 up to 2,438 tons. Under the gross weight of the test load and the cylinders themselves, the minimum pressure per square foot on the foundations was 3·80 tons, and the maximum 6·80 tons. The subsidence of the cylinders in the latter case was only 1½ in. The labor in carrying out these testing operations was very considerable, involving as it did the shifting of about 180,000 tons of weight.

Including the wrought iron arches near the north end, there are eighty-one girder spans. The following are the lengths of the girders, taking them in the order in which they are placed in the viaduct from south to north:

	No. of Spans.		Length of Girders.
South end	1	of	113 ft.
	10	"	129 ft. continuous in sets of 4 and 2.
	13	"	145 ft. continuous in sets of 3.
High Girders 13 spans.	5	"	245 ft.
	1	"	227 ft.
	2	"	245 ft.
	1	"	227 ft.
	4	"	245 ft.
	1	"	162 ft.
	11	"	129 ft. continuous in sets of 4 or 3.
	24	"	71 ft.
	1	"	56 ft.
	2	"	85 ft. wrought iron arches.
	4	"	66 ft. continuous over the four spans.
North end	1	"	108 ft. high girder.

From piers 4 to 28, 41 to 78, and 80 to 84, each span consists of four lattice girders with top and bottom members parallel, the roadway being carried on the upper members. The outside girders, excepting for six of the spans, are those which carried the roadway in the old viaduct. From piers 28 to 41 and 84 to 85, where additional headway is required, two girders only are used in each span, having curved top members, and the roadway is carried on the lower members. In the four-girder spans the first operation, after completing the piers, was to transfer the girders from the old to the new viaduct. This was effected by means of two large pontoons, 80 ft. by 27½ ft. by 8½ ft. deep, securely attached to each other at a distance of 20 ft. apart by means of connecting girders. Each pontoon was provided with two wrought iron columns, the upper parts of which were telescopic and capable of being raised or lowered about 13 ft. by means of hydraulic rams attached to the fixed portion of the columns. These two adjustable parts were connected together at the top by a cross girder, upon which the girders of the old viaduct rested while in the act of being transferred to the new one. This operation was carried out in the following manner: About the time of low water the pontoons were placed immediately beneath the pair of girders to be transferred; and the telescopic portions of the columns having been adjusted to the required height, the pontoons gradually rose with the tide, and lifted the two girders, with their cross bracing and roadway above, clear of the piers. The pontoons with their load were then floated in between the new piers, upon which the girders were let down by lowering the columns. In this position, and with rails laid along the top booms, the old girders formed a roadway upon which the new girders, slung between two travelers, were run out, and were then lowered down between them on to the tops of the piers. All four girders were then opened out to their respective positions in width on the piers, and the cross bracing and decking above were proceeded with. The work of floating out the girders for the thirteen large spans near the center of the river, and of lifting them to the tops of the piers, was still more interesting. All these girders, with their deck plating and top cross bracing, thus forming completed spans, were erected and riveted on a jetty constructed for the purpose on the south side of the river. The jetty was of sufficient size to allow of two of these complete spans being constructed simultaneously and side by side; and was provided with two openings or docks extending across it, at right angles to the direction in which the girders were built. Upon the completion of a span, the piers for which it was intended having also been finished up to the level of the top of the blue brick connections, the same pontoons which had been used in transferring the old girders, as just described, were again made use of, but stripped of their columns and connecting piece, and thus made independent of each other. These pontoons having been floated into the docks at low water, and placed in position immediately beneath the girders about to be floated out, rose with the tide, and lifted the girders clear of the blocks upon which they had been built. They were then towed out on the east or lower side of the viaduct by four steam tugs; and when opposite to and parallel with the position they were to occupy, were allowed to drift slowly up with the flowing tide until the center line of the decking was exactly in the center line of the viaduct.

In this position the ends of the girders were made fast to the piers, and were allowed to take their bearings with the fall of the tide. The next proceeding was to erect the wrought iron pier superstructures, in which the plates that would interfere with the lifting operations were only temporarily bolted in their places, so that they might be removed when necessary. For erecting these superstructures, a crane of sufficient height to command the whole work was fixed on the decking between the girders. As soon as the erection of the superstructures was completed, the next operation was to construct inside each of the four shafts a temporary column, composed of steel angles (8 in. by 4½ in. by ⅞ in.) braced together, the four columns being of sufficient strength to carry the whole weight of the span, about 520 tons. The raising of the girders up these columns was performed by means of four 13½ in. hydraulic rams, attached to the columns, and placed one under each of the end posts of the girders; and as the whole span gradually rose in 7½ in. lifts, the bolted plates in the pier superstructure immediately above the girder ends were removed to allow of their passing up the shafts, while those below were at the same time replaced and riveted up.

On arriving at their full height, the riveting of the piers having also been completed, the ends of the girders were transferred from the lifting columns to the piers themselves, and the lifting columns were taken down and removed. The raising of the thirteen large spans occupied nine months, or an average of three weeks per span. The decking or flooring is of the ridge and trough type. In the case of the high girders, where there are only two girders to the span, it is constructed with plates and channels. The troughs are 16 in. deep, and 30 in. from center to center. In the rest of the

* From a paper recently read before the Institution of Mechanical Engineers.

viaduct, where the decking has the support of four girders, the depth is reduced to 8 in., and the troughs are formed of corrugated plates, shaped in a hydraulic press, and connected on the ridges by cover strips. The whole decking is of steel, and forms a continuous flooring from end to end of the viaduct, excepting at the expansion joints.

The allowance for expansion is divided over thirty-two different places in the whole length, the sum of the calculated allowances amounting to 3 ft. 8 in. As a matter of fact, however, the spaces provided admit of a much greater variation than this. Where provision is made for expansion, the girder ends rest on rockers. The parapets or wind screens are of latticework, made of 3 in. by $\frac{5}{16}$ in. bars, with standards about every 16 ft., and finished off at the top with an oak coping. The effect they have in breaking up the force of the wind, and thereby protecting the roadway, is very remarkable. The permanent way is laid with cross sleepers, which are bedded in ballast in the troughs of the flooring, and is provided with special expansion joints, placed over those piers where the girders rest upon rocker bearings. The gradients are as follows: From south end to commencement of high girders at pier 28, 1 in 762 falling; from pier 28 to pier 32, level; from pier 32 to north end, 1 in 114 falling.

The various materials used in the construction were subjected to frequent testing throughout the work. In the case of the wrought iron the test was that it should withstand a tensile strain of 22 tons per square inch with an extension of 6¼ per cent. The following are the amounts of material used:

	Tons.
Wrought iron in girders and piers.....	19,337
Steel in flooring.....	3,540
Cast iron.....	2,470
	25,437

	Cubic yards.
Concrete (cement).....	37,000
Brickwork.....	25,700

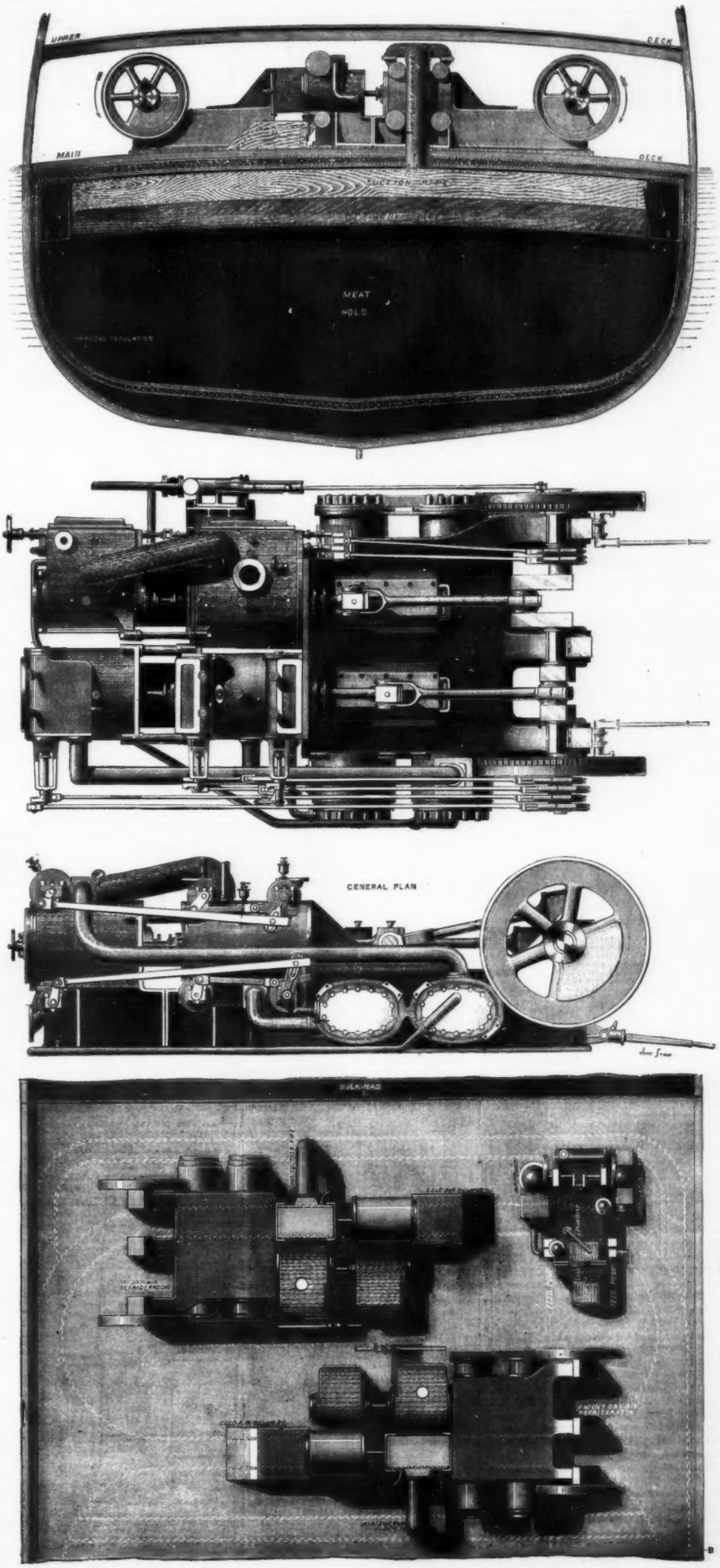
The calculations for wind pressure are based on a pressure of 56 lb. per square foot; and in estimating the area exposed to the wind, the beveled ends of the piers are considered as flat surfaces, the wind screen as a solid surface, and 50 per cent. is added to the area of the outside girders. Until this pressure is brought to bear on the structure, the holding-down bolts in the base of the pier superstructure do not come into play. The viaduct has recently been subjected to severe tests by the Board of Trade inspectors, the result being highly satisfactory. The tests were made with sixteen heavy locomotives, the aggregate weight of which amounted to 955 tons. The maximum deflection of the high girders was 1⅝ in., when the span was loaded with engines close together on both roads from end to end. The construction of the viaduct was commenced on 22d June, 1882, and it was opened for passenger traffic on 20th June in the present year, the work having thus occupied exactly five years. The engineers for the work were Messrs. W. H. Barlow & Son, Westminster; and the contractors Messrs. Arrol & Co., Glasgow.

For engravings and further particulars of this great work see SUPPLEMENT, Nos. 503, 516, and 602.

REFRIGERATING MACHINERY FOR THE STEAMSHIP FIFESHIRE.

A NUMBER of influential gentlemen interested in the frozen meat trade were lately invited to an inspection of the refrigerating machinery on board the steamship Fifeshire, recently built by Messrs. Swan & Hunter, Wallsend, for Messrs. Turnbull, Martin & Co., Glasgow, under the survey of Mr. John Wotherspoon, of Greenock. This vessel has been specially designed and built for the New Zealand meat trade, and embodies the latest improvements in marine engineering and architecture. The engines are by Messrs. Blair & Co., of Stockton, and are of the triple expansion type, for working with steam of 160 lb. initial pressure. The coal consumption will only be 20 tons per day, which is remarkably low for a vessel carrying 5,000 tons at a speed of eleven knots per hour. The forehold is entirely fitted out for meat carrying, and is insulated in the usual manner with flake charcoal between two layers of tongued and grooved boards. Practically, the whole of this hold is below the water level, so that it is not exposed to the direct rays of the sun. This is shown in the section above. The net capacity, after deducting insulation, air trunks, etc., is about 84,000 cubic feet, which is equal to the carrying of some 30,000 carcasses, or about 900 tons of frozen mutton. The cold air is admitted by a large wood trunk extending along one side, and is withdrawn by a similar trunk at the other side.

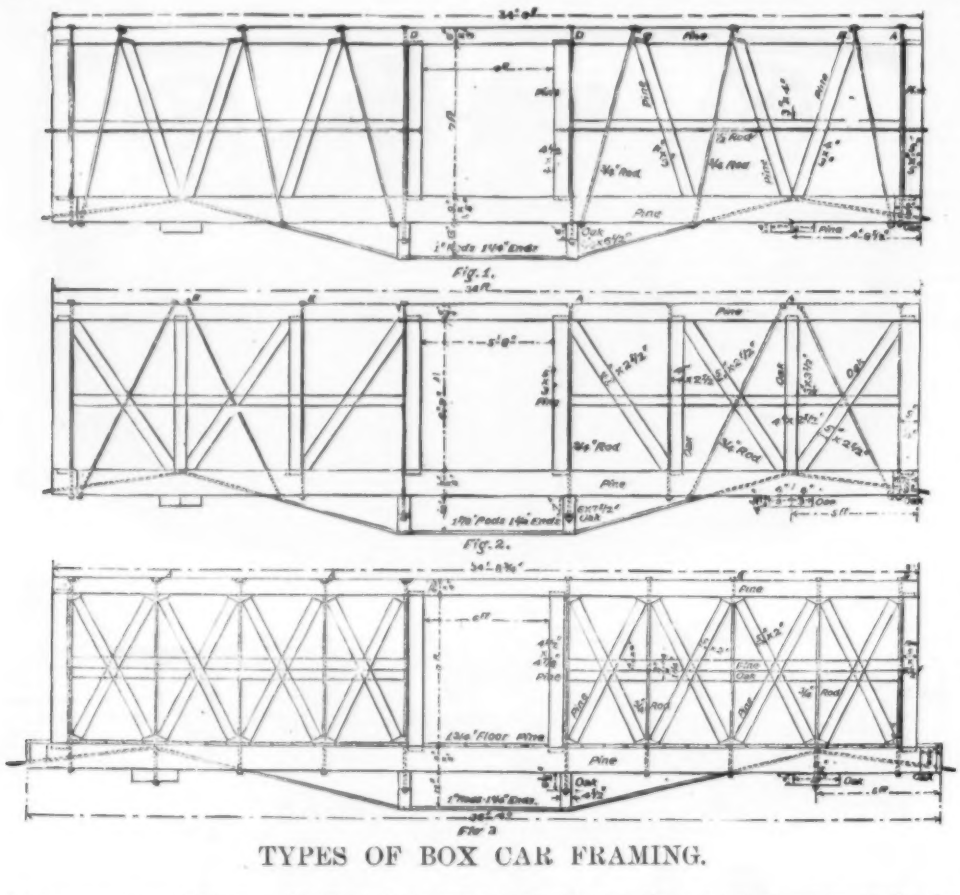
The cooling machinery, which is said to be the most powerful of the kind ever applied to ship work, has been designed by Mr. T. B. Lightfoot, Queen Victoria Street, E. C., and supplied by Messrs. Siebe, Gorman & Co., Westminster Bridge Road. It is illustrated by two views herewith, and consists of two patent "Universal" dry air refrigerators, each capable of delivering 80,000 cubic feet of cold air per hour, with an independent surface condenser common to both. The machinery is placed in the 'tween decks, above the meat hold, in a large, well lighted room. The air is drawn from the hold, and compressed to about 45 lb. per sq. inch in a double-acting compression cylinder, in which operation, though the cylinder is water-jacketed, it becomes considerably raised in temperature. It is then passed through welded steel coolers contained in the bed plate, and cooled by means of water circulated by a pump to within a few degrees of the temperature of the sea. After this the cooled compressed air is led to the expansion cylinder, where it is expanded, in the performance of work, to atmospheric pressure, and discharged direct into the trunk, cooled to from 60 deg. to 80 deg. below zero, Fah., according to the temperature of the cooling water. The compression and expansion cylinders are arranged tandem fashion, with one piston rod common to both. The driving power consists of a compound tandem steam engine with the low pressure cylinder in front, placed alongside the air cylinders, and upon the same bed plate. The steam, which has an initial pressure 160 lb. per square inch, is expanded twenty times. Great care has been taken in the design of these machines. They are got up in the latest style of best marine practice, and the materials employed have been carefully selected. One of the special features is the extreme simplicity of the apparatus, and consequent freedom from liability to get out of order, and the makers state that, out of the fifty or more machines supplied, there has not been a single instance of a breakdown. It was chiefly on this account that Mr. Wotherspoon, the superintending engineer, recommended the adoption of this type of machine for the Fifeshire, and from the inspection there seems every prospect that he will not be disappointed. The two refrigerators are placed athwartship, as will be seen by the plan of the general arrangement of the plant.—*The Engineer.*



REFRIGERATING MACHINERY, STEAMSHIP FIFESHIRE.

BOX CAR BODIES.

IT is very important that the body of a box car should be properly braced. The accompanying illustration represents three different methods in very general use, and the dimensions, etc., are taken from actual examples of the latest practice in ordinary box cars of large size.



TYPES OF BOX CAR FRAMING.

The accompanying table shows the dimensions of the principal parts of the three cars:

Principal Dimensions of Body Framing.

	Fig. 1.	Fig. 2.	Fig. 3.
	ft. in. Mat.	ft. in. Mat.	ft. in. Mat.
Length over end sills	34 6	34 0	36 4
Length over body			34 8¾
Height, sill to plate	7 0	6 9	7 0
	in. in.	in. in.	in. in.
Side sills	5 × 9 pine.	5 × 9 pine.	5 × 9 pine.
End sills	9 × 9 oak.	7 × 9 oak.	8 × 9 oak.
Transoms	6 × 16 pine.	6 × 9 (4) oak.	6 × 18 oak.
Tie beams	4½ × 6½ oak.	4 × 7½ oak.	
Corner posts	5 × 5 pine.	5 × 4 pine.	5 × 6½ pine.
Door posts	4 × 4½ pine.	5 × 3 pine.	4½ × 4½ pine.
Braces	3 × 4 pine. (Six per side.)	4 × 2½ oak.	3 × 5 oak.
Intermediate posts		4 × 2½ oak.	
Belt rail	3 × 4 pine.	3½ × 3 oak.	4 × 4 pine.
	ft. in.	ft. in.	ft. in.
Do. above top of sill	3 9¾	3 9	4 0
	in. in.		in. in.
Sub-belt rail			1¼ × 8 oak.
Side plate	3 × 6 pine.		
Corner posts rabbeted for inside lining	2 × 2		
Door posts, rabbeted for inside lining	1 × 2½		
	ft. in.	ft. in.	ft. in.
Center of transom from end of car	4 8½	5 0	5 0
Door opening		5 8	6 0

In the car body shown in Fig. 1 the bottom of the braces and posts rest in cast iron pockets, which are held in position by dowels, on the bottom, 1 in. × 1 in. These pockets are not shown in cut. The top of the braces and posts are tenoned in side plates, tenons being 1 in. × 1 in. × 4 in. on braces and corner posts, and 1 in. × 1 in. × 4½ in. on door posts. The whole being confined by ten ¾ in. vertical and angular rods and two ⅝ in. horizontal rods as shown in cut; center of transom being 4 ft. 8½ in. from end of car.

This is not altogether a satisfactory design, the objection being that, first, it is not sufficiently rigid to withstand the severe shocks to which all freight cars are subjected. The tendency is, after a continual bumping and jerking, to create a vertical vibration which will cause the braces and the nuts on the vertical and angular rods to work loose, thereby necessitating considerable attention in order to keep the car well tightened up. Secondly, there is not sufficient support to hold up the ends of the car. And thirdly, there is too much wood cut away from the side plate where the braces and rods meet.

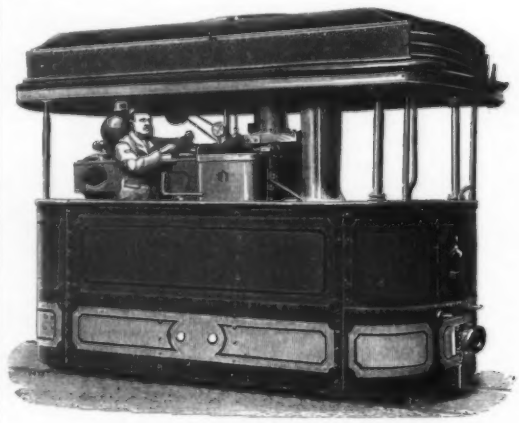
The latter is the most serious objection. On the top of the plates there are slots cut all the way across, 1 in. deep and 3 in. wide, to receive a cast iron plate which acts as a washer for the rods. Immediately under these slots there are others cut all the way across, 1 in. deep and 4 in. long, to form shoulders for the braces, and in these slots there are mortises cut 1¼ in. deep, 1 in. wide, and 4 in. long, to receive the tenons on the braces as shown. It can be noticed in the cut that the shape of these slots and their relation to one another form dangerous nicks, the stick being nearly severed at each of these places. These sticks have been broken at B in screwing up the rod at A, while the cars were being built, and again they broke at C while screwing up the rod at D, these points being fulcrums in screwing up the rods, in conforming the plates to the camber of the sills.

Care must be taken in screwing up these rods to avoid throwing the car out of square at the door. These cars are provided with the "Wagner door," and if the opening does not conform to the door, it will not go up in its place. This trouble will occur if one side of the door is screwed up more than the other.

The car shown in Fig. 2, in size and dimensions, is nearly the same as in Fig. 1, but the sides are much more rigid. It has the same number of braces and rods, and in addition to this it has a post placed at each brace as shown. These posts obviate the trouble which occurs in the car shown in Fig. 1, and the manner in which the transom post, corner brace, and rods are arranged form a very good support of the ends.

The chief objection to this car (Fig. 2) is the intermediate posts and rod heads being let into the plate. All practical men know the disadvantage of letting bolt heads into soft wood. When A A are placed outside, as at B B, a large washer can be used, which is an indispensable article for the side rods of a car. It can be readily seen that a side braced in this manner can stand much greater longitudinal shocks than that shown in Fig. 1. The dimensions and material of this car are given in the table.

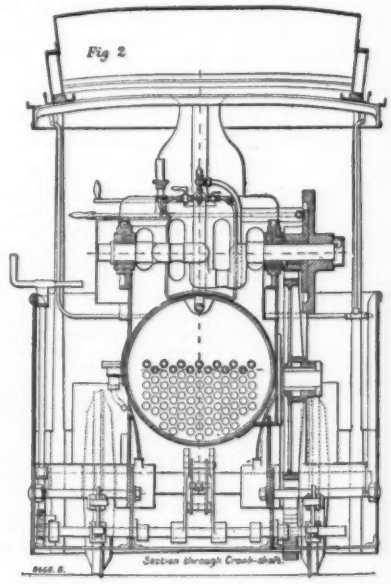
Fig. 3 shows a perfect design with one exception. If the rods, B B, with good, broad washers under their heads were adopted, instead of being let down into the wood with iron plates under their heads, shaped as shown at A A, there could be no objection whatever. The braces rest in cast iron pockets top and bottom, as shown. These pockets are held in position by dowels 1 in. × 1 in., together with the rods which pass through them. The bottom pockets are placed on the top of the floor. This is essentially the design proposed by Mr. John W. Cloud, and largely used on the Pennsylvania.—*Railroad Gazette.*

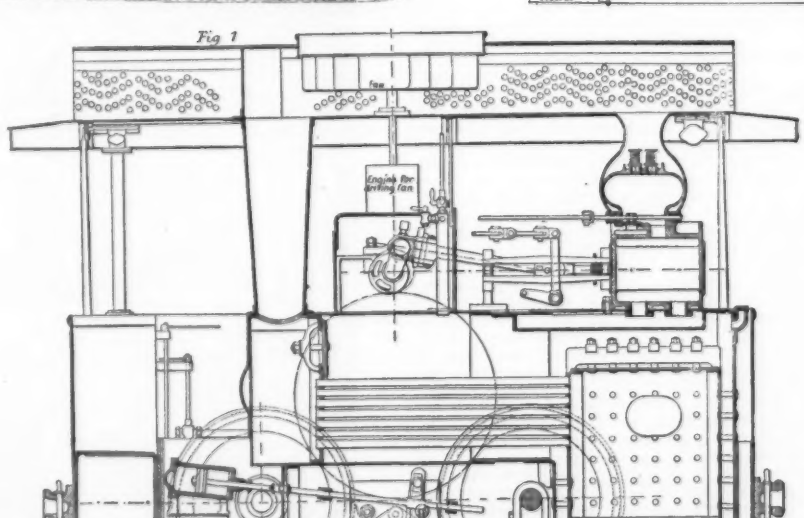


TRAMWAY ENGINE.

AT Southwick, near Brighton, on a length of about four miles of horse tramroad, experiments have been carried on, for about eight months past, with a tramway motor constructed by Messrs. Aveling & Porter, of Rochester, under the patent of Mr. Alfred Greig and Mr. T. Aveling, the object of the designers being to produce a steam engine which will work efficiently and at the same time be so contrived that many of the objections inherent in the ordinary steam motor may be avoided. The facilities they have had to observe the working of their improvements are of no ordinary nature. They have the free use of a road unrestricted by traffic regulations, and two double-decked cars capable of seating 120 person to drag about. A bountiful supply of children seems to be a characteristic of the route, so if a load is at any time wanted, here it is, ready and willing at a moment's notice.

The road itself might have been laid out for experimental purposes, so fully does it contain all the requirements—curves with a radius of 30 ft., gradients up to 1 in 18 or 20, and fixed abominations in the shape of points which are open to either road at passing places, so that it is a matter of speculation when approaching them whether the front wheels of the engine will take one road and the hindmost another, or whether cars will follow properly or take a route for themselves, and so cause a pleasing variation not usual in the conduct of such traffic.





IMPROVED TRAMWAY LOCOMOTIVE.

One of the main objections to ordinary street tram engines of the locomotive type is that the working parts are carried close to the ground, so that mud and grit find their way to them very easily; hence the wear and tear is excessive, also the cost of repairs. Another difficulty arises from the board of trade requiring that no steam or smoke shall be visible when working. To satisfy this latter requirement many contrivances more or less cumbersome and inefficient have been introduced.

The motor under consideration weighs, when in working order, 10 tons; its total length is 11 ft. 6 in.; width, 5 ft. 8 in.; height, 9 ft. 6 in.; and the gauge of road it is running on is 3 ft. 6 in. The general appearance of the engine is shown by the perspective view which we give, while the sections on the same page will explain constructive details.

The boiler is of the locomotive type; it is of steel, double riveted throughout: there are seventy-eight tubes, made of steel, 1¾ in. in diameter, beaded at the firebox end by one of Wicksteed's tube beaders. The grate area is 5 square feet; total heating surface, 148 square feet; working pressure, 180 lb.

The working parts of the engine are above the footplate, and easily accessible to the driver or cleaner. The cylinders are 5½ in. in diameter, with 10 in. stroke, and the steam is cut off at 75 per cent. in full gear; the valve chests are outside the cylinders. The engine is on four wheels, with a base of 4 ft. 6 in., the wheels being coupled by the gear which also connects them to the crankshaft. The crankshaft is 3½ in. in diameter and upon it is fixed a pinion wheel 9 in. in diameter, which gears into an intermediate wheel 3 ft. 4 in. in diameter, revolving on a stud axle fixed to the side of the boiler; this wheel again gears into toothed wheels 27 in. in diameter fixed to the driving axles. The speed of the crankshaft pinion is three times that of the road wheels. The increased piston speed thus obtained is of advantage in starting.

The ordinary system of springs has to be abandoned, for the axles and crankshaft must maintain their relative distances. Hence, to take up the jar from the road, wheels with self-contained springs are introduced. The wheels are 3 ft. in diameter, and the spring acts on the movable tire, giving a play of about ¼ to ⅜ of an inch. These spring wheels, we may mention, are a modification of those which Messrs. Aveling & Porter have, for some time past, been applying to their traction engines, and the good performance of which, on such engines, we have had occasion to notice.

To do away with the discharge of visible steam and smoke, the steam from the cylinders passes into a tank on the footplate, to take up any priming and allow the steam to expand before passing to the condenser, which is arranged over the roof of the engine. It consists of a number of 1 in. tubes placed transversely and exposing a condensing surface of 208 square feet. The ends of the tubes lead into longitudinal boxes with divisions, to cause the steam to pass to and fro in its passage from one end of the condenser to the other; the steam enters the condenser at the fire box end, and any surplus passes down a pipe into a tank fixed below the footplate at the smoke box end. In this tank any water mingled with the steam is separated, and such steam as remains uncondensed passes to the exhaust nozzle arranged in the chimney in the ordinary way. To assist condensation a fan is arranged in the roof, and exhausts the air from among the condenser tubes. A continuous stream of cold air is thus induced athwart the tubes. A special feature in the arrangement is the manner in which the fan (which is one of Blackman's air propellers) is placed so as to partially overlap the top of the chimney. It thus partially exhausts from the smoke box, insuring the necessary draught and, moreover, effecting a thorough mixture of the hot gases with any exhaust steam which may remain uncondensed, the result being to render it invisible. The fan is driven by a small independent vertical engine placed alongside the chimney.

The tank on the footplate feeds an injector, and the low tank at the smoke box end supplies a pump driven from the crankshaft. With this system of condensing it is stated that about three-quarters of the vaporized water is caught and returned to the tanks to be used over again.

There is a hand brake and a steam brake, both under control of the driver. Automatic gear also applies the brakes and shuts off steam when the speed attains nine miles per hour. The speed is shown by a speed indicator driven from the crankshaft.

We lately had a run with the engine under notice, and neither smoke nor steam was visible during its working. The Blackman fan effectually dispels the escaping products. Gas coke is used for fuel, and the manner of stoking is to fill up the fire box at each end of the run. It may perhaps be found advantageous to work this motor with low cars without an upper deck, as the fumes from the fuel are disagreeable, the absence of a high chimney intensifying this objection. Major-General Hutchinson, the inspector for the board of trade, has passed the engine.—*Engineering.*

THE CHANGE OF GAUGE OF SOUTHERN RAILROADS IN 1886.*

By C. H. HUDSON.

WHEN Horatio Allen recommended a 5 feet gauge for the South Carolina Railroad, he little thought that half a century later an expenditure of over a million dollars would be required to undo his work. He did not expect an extension of the iron rails, within that time, from ocean to ocean, nor that necessities would arise for running cars from one extreme of the country to the other. His successors, in later years, were little wiser.

Time, however, has shown that prompt and economical transportation requires that our car, once loaded, shall go to its destination without transfer. To this end, the 6 feet lines attempted to extend their wide gauges to distant centers of trade; while the 4 feet feet 8½ inch and 4 feet 10 inch gauges tried to compromise their troubles by changing the tread of their wheels from the 3½ inches of the early lines to 5 inches, that they might run on both gauges. This was not altogether satisfactory, and another attempt was made to harmonize matters by the use of a compromise gauge of 4 feet 9½ inches. This did better, and in time the 4 feet 10 inch, or "Ohio" gauge, was changed to this or its successor, the 4 feet 9 inch. The 5 feet 6 inch gauge became a thing of the past, and the 6 feet either became "standard" or laid a third rail, so that either "wide" or "narrow" trains could be run, and all equipment be kept in use until it was narrowed, when the third rail could be taken up. It became possible to run a car from the Atlantic to the Pacific, north of the Ohio river and west of the Mississippi river. South of the Ohio and east of the Mississippi, however, the universal gauge, save a few roads, was 5 feet. Interchanges of cars were not thought necessary, and all freight to and from this section had to be transferred from car to car. This burden was realized by both railroads and shippers, and arrangements were made to exchange trucks, till not a prominent point could be found on the border without its "hoist" and acres of extra trucks. This was expensive, both in time and "plant," and a change of gauge, which would do away with these "hoists" and the time and labor required to operate them, began to be talked of. Few, however, had the courage to think of it as a thing of the near future.

The Illinois Central Railroad was the first line east of the Mississippi to meet the question and make its southern end conform in gauge to its northern, which it did in 1884, giving a continuous 4 feet 8½ inch line from New Orleans to Chicago.

Under the pressure of competition, the Mobile & Ohio Railroad followed, and in July, 1885, changed to 4 feet 8½ inches.

The most direct competitors of the Mobile & Ohio Railroad, the Louisville & Nashville and Cincinnati Southern systems, saw that they, too, must change, or be at a disadvantage, and determined so to do.

Other large systems realized that they could delay no longer, but must move with the Louisville & Nashville and Cincinnati Southern. The smaller roads had no choice in the matter, but must join the ranks.

At a meeting of the executive committee of the Southern Railway and Steamship Association (presidents of the various lines) held in the summer of 1885, a committee of general managers of the principal lines was appointed to take up the matter, formulate plans and fix dates, that there might be harmonious working and the least possible delay and discomfort to the public.

This committee met in New York in October, 1885, but nothing like a general or satisfactory discussion was had. The more the managers looked into the matter, the more they were impressed with its magnitude, and the need for co-operation. Our chairman was requested to call a meeting of the managers of all lines interested, with the request that the heads of their transportation, machinery, and maintenance of way departments be present to aid in the consideration of the questions. This convention was held at Atlanta, Ga., February 2 and 3, 1886, with seventy representatives, of various grades, of thirty roads. Tuesday, June 1, was fixed upon as the day for the general change, though some six or eight roads, for local reasons, were to change on Monday, May 31. It was also agreed that branch lines might be changed at such other times as best suited the owners, the general change being so conducted as to best promote the interests of the through lines. Committees were appointed on transportation, roadway, and machinery, to discuss in detail matters pertaining to the various departments and to report to the convention for final action.

The matter of the proper gauge to which we should change was taken up by the convention itself, and a lengthy discussion followed. It was urged by one important line, whose business was mostly with Northwestern roads, that 4 feet 8½ inches was the true gauge to be used. The greater parts of the roads changing, however, had their largest interchange of business with the East and Northeast, and consequently with the Pennsylvania Railroad system. There must necessarily be a large interchange of cars with that road, and it would follow that the gauge used should readily admit Pennsylvania Railroad cars, and that our cars must be acceptable to that road. It is true that the Pennsylvania Railroad cars do run on the Northwestern, or 4 feet 8½ inch roads; but it was the experience of several who had worked both gauges, that to haul a given number of cars upon a 4 feet 8½ inch track required more power than upon a 4 feet 9 inch track, because of the greater friction between the wheels and the rails; the flanges in one case clearing the rail by three-fourths of an inch, while in the other the clearance is one-fourth of an inch, and sometimes less, especially when the trackmen have the track gauged a little too close—not an uncommon thing to find. Again, it is not an unusual thing for a wheel to be carelessly put on, and be too wide.

It was the writer's experience, a few years ago, while connected with a 4 feet 8½ inch road, to send some P., Ft. W. & C. cars to the Mississippi river loaded. They were undoubtedly a little too wide and the track in the yard where they went was a little too narrow. The inspector found something wrong, and actually took the trucks out from under the cars and replaced them with narrow trucks, upon which he sent the cars to Chicago, while he loaded the wide trucks upon flats and returned them home in that way.

One road in Ohio, formerly a 4 feet 10 inch "Ohio" gauge, changed to 4 feet 8½ inches, and after a few months' experience again changed to 4 feet 9 inches, and found that it was freed from many trials due to small clearance between flange and rail.

It was at last decided that we would make 4 feet 9 inches our gauge. This discussion brought out a special committee on wheel gauge, who were to take up that question in connection with other roads of both gauges and report at an adjourned meeting on the 16 of February.

The transportation committee reported upon the transportation feature of the problem, which chiefly pertained to the handling of loaded and the return of foreign cars prior to the change, in order that each road might have only its own cars on the day of change, or the fewest possible cars of other roads.

The machinery committee treated upon the matter of changing cars from a general standpoint, in order that the work upon those away from home, or upon foreign roads, should be done in the manner desired by the road owning the cars. Beyond that, they left each road to do its own work in its own way.

The committee on roadway went more into detail, and based upon the experiences of the Mobile & Ohio, and such other information as they could obtain, reported as follows:

"We are of the opinion that no fixed rules can be adopted to suit all cases; but make the following general suggestions, which we hope will aid all in carrying out the difficult problem which we have to solve.

I.—CHANGE OF GAUGE.

First. On such day or days as shall be designated by the convention, the gauge of the track should be changed from 5 feet to 4 feet 9 inches, by moving in one or both rails, which rail, if but one, to be determined by each road itself.

Second. The entire line between.....and..... should be changed on..... .....

Third. The masters of roadway on each road should assign the foreman for each section for the days of change, and issue such detailed instructions to supervisors, in addition to the general orders issued, as may be necessary.

Fourth. Each road should fix its own rate of pay for hands.

II.—PREPARATORY.

First. Supervisors should see that railroad crossings, switch tie bars for split and stub switches, and castings and bolts for Wharton switches, are at the places required five days before the day of change. Foundations for railroad crossings should be examined, and when necessary new foundations should be framed ready for use on the day of change.

Second. Supervisors should provide each gang foreman with two adzes, and on May 1, 1886, preparation of the roadbed for the change of gauge should be commenced, to be completed five days previous to the change of gauge. This preparation should consist of adzing the ties to a smooth and even surface with base of rail and clearing any obstructions even with the top of the tie for a space of not less than five inches from the rail that is to be moved in.

Third. Supervisors should also provide every gang foreman with two templates for setting inside spikes, and five days previous to change the work of drawing and setting inside spikes should commence. All inside spikes on the side of the track that is to be changed should be drawn, except the spikes in every third tie on tangents and every other tie on curves and one inside spike at every joint. Spikes should be set with templates in every third tie on tangents and every other tie on curves (not in same ties where inside spikes are left). Spikes should be set straight, and should project above the top of the ties not more than 1½ inches and not less that ¾ of an inch under the heads.

Fourth. All spikes drawn from inside of rail and not redriven before the day of change must be straightened and placed on ends of ties in which the inside spikes for change of gauge are driven.

Fifth. All roadway forces, where necessary, should be increased not later than thirty days prior to the day of change, so that by the day of change all such forces should be at least double regular number. On day or days of change there should be not less than three men to the mile, each road to divide them into squads to suit itself. On the day of change, service or material trains (engines and cars of standard gauge) should be furnished, said trains to cover that day not more than seventy-five miles.

Sixth. For a section of eight miles, with a gang of twenty-four men, the following tools should be provided:

1 5 feet gauge pole car.
1 standard gauge level car.
10 spike mauls.
10 clawbars.
2 axes.
2 adzes.
2 standard track gauges.
2 track wrenches.
1 water bucket.
1 water barrel.
2 tin cups.
4 extra spike maul handles.
32 kegs spikes.
1 monkey wrench.
2 cleavers.

This list should be increased or decreased proportionately as section is increased or decreased.

Seventh. Meals should be furnished for the forces on day of change by the railroad companies.

Eighth. All track that can be spared from use should be changed previous to the day of the regular change.

III.—ON DAY OF CHANGE.

First. The gangs should reach the position assigned to them at the hour specified on the day of change, and beginning after the last train passes, which train should be provided with a special signal, to be designated. They should work in the direction designated until they meet, regardless of section limits.

Second. The gauge of main line should be changed first, and afterward the force will return to the various sidings and change them as rapidly as possible, being sure to have their entire work done at sunset, or as much earlier as possible.

Third. The organization on day of change for eight mile sections should be as follows:

4 men drawing inside spikes.
8 men driving outside spikes.
4 men driving inside spikes.
4 men throwing rail.
1 man with 5 feet gauge pole car.
1 man with standard gauge level car.
2 men extra.

Fourth. An outside spike should be driven in every tie where there was an inside spike previously driven for standard gauge, and both should be driven down close to the rails.

Fifth. In changing railroad crossings, the gauge of the crossing road should not be changed unless specially ordered by the superintendent through the master of roadway.

Sixth. In the matter of moving the outer rail on very sharp and long curves, if the rails jam, it is considered that the difficulty can be remedied by throwing the track outward. The amount of this jamming should be ascertained beforehand, and curves should be previouly adjusted to prevent jamming on day of change.

* A paper read before the Western Society of Engineers, June 7, 1887.

IV.—AFTER CHANGE OF GAUGE.

First. Immediately after change of gauge, gangs should proceed to full-spike their entire track, drawing and removing all old spikes for that purpose.

Second. The following order should be observed in spiking track after change of gauge:

1st. Spike turnout curves.
2d. Spike main line curves.
3d. Spike bridges and trestles.
4th. Spike main line tangents.
5th. Spike siding tangents.

Third. Foremen should be provided with tickets for paying their men on completion of change, and these tickets should be cashed by the nearest agent on presentation."

Upon February 16, the convention met, pursuant to adjournment, to receive and consider the report of the committee on wheel gauge. This committee sent circulars, upon the subject of wheel gauge, to a large number of roads, both 4 feet 9 inches and 4 feet 8½ inches gauge, in order to get their ideas and experience. At the same time a sub-committee was started upon a tour of investigation, to learn what they could upon the matter. They visited a large number of roads and saw the practical workings, and consulted with the most experienced car builders in the country. After a careful examination of the information thus obtained, the committee reported:

"We recommend that 4 feet 5⅜ inches, allowing variations of ⅛ of an inch either way, be adopted as a standard gauge between flanges, and further recommend that the limit gauge of the Pennsylvania Railroad be adopted; that is, the smallest distance between flanges be 4 feet 5 inches, and the smallest distance from out to out of the tread of the wheel be 5 feet 4 inches. Any wheels measuring less than allowed by these limits to be rejected."

This was exactly what the master car builders had fixed upon as the proper gauge for wheels; but which only stood as a recommendation, never having been accepted as a standard by any roads. The following statement shows the gauge, distance between flanges, and lateral play of a number of large systems:

Gauge track. Ft.	In.	Name of road.	Distance between flanges. Ft.	In.	Lateral play. In.
4	9	Pennsylvania	4	5⅛	¾
4	8½	Illinois Central	4	5⅜	⅜
4	8½	C., B. & Q.	4	5⅜	⅛
4	8½	L., N. A. & C.	4	5⅜	..
4	8½	N. Y. C. & H. R. R.	4	5⅜	..
4	8½	Missouri Pacific	4	5½	½
4	8½	L. S. & M. S.	4	5¼	¾
4	9	Rich., Fred. & P.	4	5⅜	¾
4	8½	Balt. & Ohio	4	5¼	½
4	8½	C., M. & St. P.	4	5⅜	⅜
4	8½	C. & N. W.	4	5⅜	⅜
4	8½	St. P., M. & M.	4	5⅜	¼
4	9	Ches. & Ohio	4	5½	¾
4	8¾	Pitts. & L. E.	4	5½	¼

It will be seen that the report was based upon the practice of many roads, and would undoubtedly give satisfaction to all. It was adopted by the convention.

The general plan had now been blocked out, and individual work could commence with reasonable assurance that it would be in harmony with that of other roads. The various officers had studied the problem to some extent before the meeting and had worked out many details in their own minds. They were thus enabled to compare notes, and avail themselves of the thoughts of others, gaining much valuable information. Some prepared and printed very elaborate instructions, intending to cover the minutest detail of the work, so nobody could possibly err, only to find that the practical man on the track or in the shop discerned "snags" unthought of by the formulator of the instructions, and also found ways to overcome the difficulties, and in many cases was able to do his work in a better and cheaper way than was pointed out in the instructions.

The more general way was to print and issue only the general instructions, leaving much for department heads to work out according to the conditions surrounding them. Frequent and full personal consultations were found to be useful. The work was of an extent and character, all things considered, never before undertaken, and must be done at the time selected. There would be no chance to wait and see what others did or to correct mistakes.

The work of preparation was spread over several months, and in fact was much more of a problem than the mere moving of the one rail three inches. The engines and cars were of varied construction, and the conditions and facilities varied with the various roads and localities. A rule which would work well in one place would not of necessity be the best in another. A process which would be good upon one road might not be the most economical in another. So the officers of each line tried to look at their problems with their surroundings, and decide for themselves how much of the general plan they could follow.

I give briefly some of the plans and methods in both track and machinery matters, showing how details were handled.

While several roads had changed gauge, the conditions varied much from these we now had to meet. In former cases there were plenty of neighbors or connections from whom cars could be borrowed to keep their traffic moving, while in ours everybody had to look out for himself, and could not help his neighbor if he would. We must take care of our traffic and change our cars at the same time. To do this we must withdraw a part of our equipment from service, and change it prior to the change of the track, giving us something to use as soon as the track was changed. Necessarily, this would inconvenience the public somewhat; but there was no other way out of the trouble, though a loss of earnings would follow.

It was argued by some that the proper way would be to provide entire new sets of wheels and axles, so that, at the change, the least possible time would be used in the transfer. The general idea, however, was that it would be very expensive and unwise. When we consider that with 13,000 miles of main track and 1,590 miles of side track there were 1,800 engines and 40,000 cars, we see the great cost of that plan. 327,000 new wheels and 163,000 axles could not be thought of, even if we did have nearly as many wheels and axles left over to be used in repairs. We must withdraw our cars, and if possible get half of them changed before the first of June.

Cars so changed would be "parked" upon tracks, which would be prepared for the purpose, near the shops where the change was made. When the day of change came, it would be necessary to gather in all the remaining broad gauge cars at the same points and "park" them upon these tracks, unless the road should be fortunate enough to have a large surplus of broad gauge tracks that were not needed for traffic. Very few Southern roads had this, and the extra tracks were, as a rule, laid. A system with 5,000 cars would need about 30 miles.

Just how much would be needed at each point was a matter of conjecture, as no one could tell in advance how many cars would be changed at any one point, or how many broad gauge cars would be hauled there at the last minute. Storage tracks, as a rule, could not be built very near the shops where the changes of trucks were made, so that tracks had to be laid connecting them with the shop tracks.

The shop tracks were so arranged that both wide and narrow gauge trucks would run upon them. This was as a rule done by putting some guard rails inside the 5 feet track, 4 feet 5 inches out to out, so that the tread of a wheel of the narrow truck would be kept on the rail of the 5 feet track. (See Fig. 1.)

Some were laid with the outer rails 4 feet 11⅛ inches apart, and without guard rail. This, however, did not give good satisfaction, as the bearing surface was so small that a slight imperfection in the rail, or a curve that let the wheel run to one side, would cause a wheel

FIG. 1

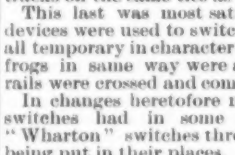
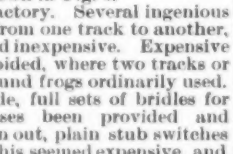


FIG. 2.



to drop in and give trouble and delay. The tracks from storage yards to shops were sometimes laid with a guard rail (Fig. 1), and at others with two separate tracks on the same ties as shown in Fig. 2.

This last was most satisfactory. Several ingenious devices were used to switch from one track to another, all temporary in character and inexpensive. Expensive frogs in same way were avoided, where two tracks or rails were crossed and compound frogs ordinarily used.

In changes heretofore made, full sets of bridles for switches had in some cases been provided and "Wharton" switches thrown out, plain stub switches being put in their places. This seemed expensive, and would take up much valuable time on the day of change.

We had various kinds of bridles. The old-fashioned ones for the stub switches, that clasped the base of the rail, as shown in Fig. 3, was cut near its center and had one end lengthened; each part being at least 2 feet 9 inches long. Three holes were either punched

FIG. 3.

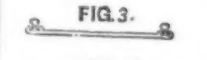
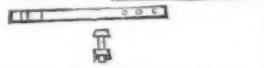


FIG. 4

FIG. 5.



or drilled through the bars near the end, the outer one 2 feet 7½ inches from the inside of the rail head, the next one 3 inches inside of that. This made the bars all alike, and no care had to be used to pick "rights" and "lefts."

These were put on the 5 feet gauge by placing the outer hole of one bar over the second hole in the other; a bolt was then put through, a nut put on the bolt, and a spring cotter put in hole which had been drilled through the bolt. Another bolt through the other holes, and the bar was secure. On the day of change the bolts were easily removed, the bars moved 3 inches, the bolts replaced, and our track was 4 feet 9 inches.

Fig. 4 shows the bars as changed and ready to be put together.

Fig. 5 shows a bar which took hold of the flange of the switch rail, treated in the same way.

Fig. 6 shows another kind, and the manner of its treatment is readily seen by the sketch. A hole is drilled 3 in. back from the one through which the original rivet or bolt was put. The manner of change is readily seen.

With the "Wharton" there was more trouble, as the

FIG. 6

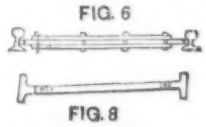


FIG. 7

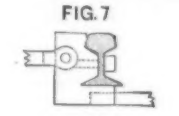


FIG. 8

bars could not easily be removed to be prepared for change. It was found, however, that a casting could be made that could be placed behind the elevated rail, which would hold it in 3 in. securely, a longer bolt being needed.

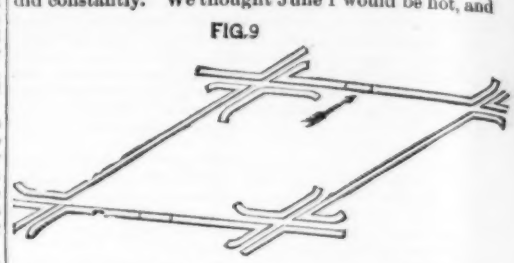
Figs. 7 and 8 show this so plainly that no further description is needed. Five each of these bolts and castings were needed for each switch. The safety throw bar was simply disconnected to be lengthened and replaced at leisure.

Crossings were prepared by cutting out at the center the requisite length, and then keeping the piece in place by splice bars till the day of change, when the cut pieces were taken out and one side moved up to proper gauge. (See Fig. 9.)

It was decided that the "gauge" rail was the one to be moved. On lines without curves, or with very few, this was undoubtedly correct; but where curves were frequent and long, some provision must be made to overcome the "crowding." The committee recommended that the track be thrown out. The tendency of trackmen is so strong to run the tangent into the curve, and so much of our line was curved (45 per cent. upon one division, a large part of the curves being 6 degrees and upward), we felt that we must have some other remedy.

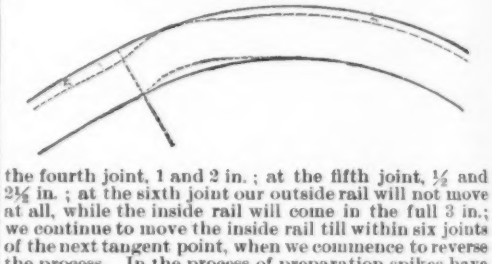
Fig. 10 gives an idea of the plan of the committee. It was claimed that we could cut rails so as to leave room; but our grades were high, and we felt that in the days that would elapse between any such preparation and the day of change our track would "run," as in fact it did constantly. We thought June 1 would be hot, and

FIG. 9



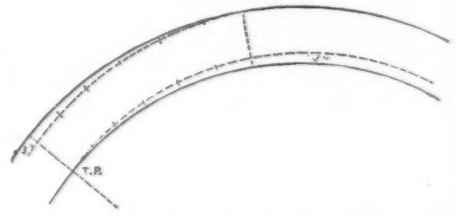
thus any gap we might calculate upon surely be closed up. All this, of course, where the outside rail was the one to be moved. It seemed better to us to change sides, and in all cases move the inside rail. To do this we would change the "gauge" rail up to the tangent point the regular 3 in., the joint first beyond the tangent point (which we will assume at a joint nearest the actual T. P.) we will throw in 2⅛ in., while the other rail will come in ⅛ inch; the second joint in same way will go in 2 in., while the opposite rail comes in 1 in.; at third joint the distances will be 1⅛ and 1½ in.; at

FIG. 10



the fourth joint, 1 and 2 in.; at the fifth joint, ½ and 2⅛ in.; at the sixth joint our outside rail will not move at all, while the inside rail will come in the full 3 in.; we continue to move the inside rail till within six joints of the next tangent point, when we commence to reverse the process. In the process of preparation spikes have been driven at each of the points mentioned. Fig. 11 shows this plan.

FIG. 11



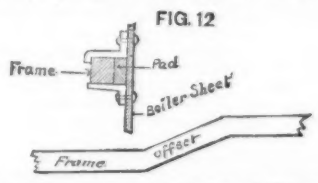
The outside or elevated rail is the one usually used as the line rail upon a curve, so we were following the plan on which we started, viz., to move the "gauge" rail. The wisdom of the plan was shown when the day of change came, and curves changed on this plan were found to be in better line than those changed by any other method. We tried all three plans spoken of.

In the matter of locomotives the conditions varied much. Of the engine builders, the Baldwin Locomotive Works had probably been the most farseeing. For twenty years they had looked forward to this change, and had during that time so constructed their frames and fire boxes that, by using new driving wheel centers, the change could be made without changing other parts. Few other builders had, until comparatively recently, given the matter any thought, and as a result many engines were found that could be changed only by moving the frames in, and not unfrequently the fire box had to be altered. This meant a new fire box and heavy expense. Many engines were thrown out of service by the fact of the great cost of changing them.

The 5 ft. engines measured between flanges of drivers (and other wheels as well) 4 ft. 8¾ in. As the gauge was narrowed 3 in, it followed that the new measurement would be 4 ft. 5⅜ in., and this in fact was the measure fixed upon by the convention, with a limit of variation of ⅛ in. either way; so the frames must be enough less than this from out to out to give a reasonable clearance, or say 4 ft. 5 in. I think all our Baldwins were within this limit; but we found other engines wider from out to out of frames, the frames being set out from the fire box and a "pad" placed between them. (See Fig. 12.)

The "pad" could be cut out and the frame set in against side of the fire box; but to do it, this frame had to be offset, as shown in Fig. 12. This was done

FIG. 12



behind the rocker arm and in front of the pedestal or "jaw," thus rendering unnecessary the changing of machinery, but enabled us to set in the boxes and wheels or tires to the proper width without cutting into the frame.

To get proper information about all the engines, accurate measurements were taken of width of fire box, width between frames, from out to out frames, between hubs, between inside of tires, between rims of wheels, sizes of boxes and wedges, thickness of hubs, rims of wheels, etc.

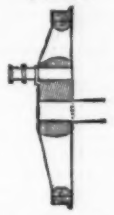
Blue print diagrams were prepared upon which were placed all these measurements, with the number of the

engine. From these the head of the machinery department could see at a glance what was required for each engine.

It was expected at the start that new driving wheel centers would be required for all engines; but examination of our blue prints showed that upon our lines, at least in a majority of cases, this was not necessary. Some few engines, notably some of the old Rogers, had wheels that were dished to such an extent that by pressing them off and putting on again, with the outside face inside, an inch and a half could be gained and the tire could go on as originally placed, squarely upon the wheel. See Fig. 13 as originally, and Fig. 14 as turned.

FIG. 13

FIG. 14



It was found in practice that a new crank pin had to be put in. In many cases we found that we had thick hubs and heavy flanges to both driving boxes and wedges, so that by taking from ⅛ to ¾ of an inch from the inside of the hubs, and ¼ to ¼ from the box and wedge flanges, we could gain at least one inch, and in some cases did more. This left not to exceed half an inch for the tire to project over the wheel center on the inside, neither an unreasonable nor an unusual projection. This change was a trifling one and done at a cost per engine of $130.67, including new crank pins.

A new set of wheel centers, finished and in place, including pins, which would probably be needed, would cost $264.46.

When changes were decided upon, and an engine was in the shop, they were made, and the tires were then put on at the old gauge, projecting outside the centers. They were used in this way without trouble until the day of change came. Fig. 15—original. Fig. 16—changed.

Some of the more recent engines had their wheel centers built expressly with a view to changing. They

FIG. 15

FIG. 16

FIG. 17

FIG. 18

were placed upon the axle, as would be required with the new gauge; but the rim projected outwardly an inch and a half more than usual, so that the tire could be placed for the five feet gauge and still have its full support. (See Fig. 17.) When the tire was eventually moved to the narrow gauge, this outward rim would be turned off.

Of course, we were not able to take all our engines into the shop and press in their wheel centers; so had to be satisfied with some temporary arrangements that would give us the use of the engine until such time as it could be taken into the shop. We decided to set tires in leaving the centers unchanged. This gave an inside projection of one and one half inches plus what little projection there might have originally been.

When the rim was solid, there was no trouble in this (Fig. 18), provided the tire was not too thin. We fixed upon two inches as a limit of thickness safe beyond doubt.

When the coring was in the middle and not large this was still safe. (See Fig. 19.)

We sometimes, however, found very large cores, and at one side (see Fig. 20), which gave us a very small hold for our tire, and it was not deemed safe for road service. To overcome this danger, we purchased a few new tires 6¾ in. wide, with the outer corner cut away, as shown in Fig. 21. This gave us a bearing over the entire

FIG. 19

FIG. 20.

FIG. 21

rim of the wheel, and was safe, no matter how large or in what position was the core. The corner was cut off to save material and at the same time to save the bad effects of a wide tire upon frogs and switches. The edge was left one inch thick. At some future time, when the engine goes into the shop and has new centers put on, or the old ones pressed in, this extra width of tire can be turned off.

As to engine trucks: The frames had, in many cases, been made of the proper width for the narrow gauge, and the wheels had been built with a heavy hub projecting an inch and a half inward (Fig. 22), so that it would bear against the truck box. It was expected that these wheels would be taken out and one inch

FIG. 22

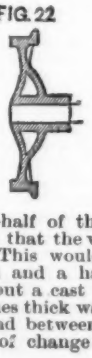


FIG. 23

and one-half of the hub taken off when the change came, so that the wheel could be pressed on the new gauge. This would have taken too much time; so the inch and a half extra hub was left off all new wheels, but a cast iron collar or washer one and one-half inches thick was placed upon the axle inside each wheel and between it and the box (Fig. 23). When the day of change came, a few blows of the hammer upon a cold chisel split this collar off, and we were ready to press the wheel the needed inch and a half upon the axle.

(To be continued.)

[Continued from SUPPLEMENT, No. 621, page 9922.]

HISTORY OF SUBMARINE MINING.

By SAMUEL RODMAN, Jr., U.S.A.

THE zeal with which submarine mining was carried on by the South attracted attention in the North. Means were at once devised for removing such obstructions. Countermining was resorted to, and small boats were sent out with drag ropes and chains to fish them up. When countermining, a large raft, with a huge torpedo suspended in front, was pushed among the mines. In this way a passage for a fleet could be cleared. At the attack upon the works in Charleston harbor, April 7, 1863, the monitor Weehawken was provided with such a raft, but as it proved a great impediment to her movements, and by no means fulfilled expectations, its use was afterward abandoned, and nets, booms, and drags were resorted to instead.

The results obtained with submarine mines were of two kinds—direct and indirect. The latter not from actual loss of vessels, but from necessary delays in removing mines, whereby quick and decisive co-operation of land and naval forces was impossible.

Among the direct results during the rebellion, the following may be mentioned:

The ironclad Cairo was sunk in the Yazoo river, December 12, 1862; a mine exploded under the monitor Montauk, in the Ogeechee river, February 28, 1863, but her commander saved the vessel by promptly running her ashore; the ironclad Baron De Kalb was sunk in fifteen minutes by the explosion of a Singer torpedo under her, in the Yazoo river, July 12, 1863; on August 8, 1863, the gunboat Barney was badly damaged by a mine in the James river; a floating mine completely destroyed the transport Maple Leaf, in the St. John's river, April 1, 1864; in March of the same year, the ironclad Eastport was destroyed by a mine, during the Red river expedition; in the joint attack of Admiral Lee and General Butler against Drury's bluff, on the James river, the Commodore Jones was literally blown to pieces by a large electric mine; the loss of the monitor Tecumseh, together with her commander and seventy officers and men, occurred at Farragut's brilliant forcing of the entrance into Mobile bay in August, 1864; in December of the same year, the gunboats Otsego and Bazeley were destroyed by mines in the Roanoke river; on January 15, 1865, the monitor Patapsco was blown up in Charleston harbor, and sixty-two officers and men went down with her; on March 1, 1865, Admiral Dahlgren lost his flagship Harvest Moon by a sea mine; the union steamer Milwaukee was sunk by a torpedo in the Blakeley river, on March 28 of the same year; on the following day, the federal ironclad Osage was sunk just inside the bar, at the mouth of the Blakeley river, by a mine exploding under her bow; on the 29th of April, 1865, the federal steamer Rodolph, while on her way with material for raising the sunken Milwaukee, struck a mine and went down in a very few minutes; and on April 14, 15, and 16 of the same year, the federal steamers Sciota, Ida, and Althea were sunk by mine explosions. The foregoing were all union vessels, and were destroyed by mechanical and electric mines of the defensive class. Offensive torpedoes and submarine torpedo boats were also used. The latter were cigar-shaped, pointed at both ends, built of sheet iron, and were scarcely visible above water. The torpedo was carried at the bow, and these little boats, jokingly called Davids, attained a speed of seven knots an hour. One of them exploded a torpedo under the federal steamer New Ironsides, lying off Charleston, in December, 1863, but did little damage. The carelessness in patrol duty at night by small boats was the cause of the David being allowed to approach the steamer; and although strict orders were afterward issued to commanders of vessels that all possible precautions against surprise should be taken, they were not sufficiently well carried out in all cases to prevent a repetition of what had happened to the New Ironsides, for on the 17th of February, 1864, a similar attack was made upon the federal gunboat Housatonic, lying in the outer channel off Charleston, and she was sent to the bottom. An attack was made, March 6 of the same year, upon the federal man-of-war Memphis, then in the North Edisto river, but no success attended it. A similar attack, but also without success, was made upon the federal frigate Minnesota, April 9, 1864, when she lay at anchor in Hampton Roads, off Newport News.

The success attending the use of torpedoes by the South attracted great attention in the North, and as naval operations, at least, were conducted on the offensive, it was thought that spar torpedoes would be the most effective. The brilliant achievement of Lieutenant Cushing, U. S. Navy, in destroying the confederate ram Albemarle, lying off Plymouth, North Carolina, was rendered eminently successful by the use of a torpedo of this class. The following general description is given: The case was a copper cylinder, through whose entire length ran a hollow tube. At the lower end was a fulminate cap, and at the upper an iron ball held in position by a pin. To the latter was attached a string leading into the boat. The torpedo case had two compartments, the upper an air chamber, the lower for the charge. The whole affair was carried at the end of a spar and held there by another pin with a string leading into the boat. The spar with the torpedo was to be pushed out when near the vessel to be attacked, and the torpedo released by drawing out the pin which held it to the spar. The torpedo would then gradually sink, and at the proper moment the other pin holding the ball would be withdrawn, allowing it to fall on the fulminate below. Lieutenant Cushing's attack on the Albemarle was made the night of October 27, 1864, and was a complete success. It was considered as one of the most glorious affairs of the whole war, and created a great sensation. That Lieutenant Cushing should have been able, with an ordinary steam launch, to approach within twenty yards of the Albemarle and not be seen, shows that there was great carelessness in picket duty on the ram, and it became apparent that in future, when an enemy would be on the lookout for such an attack, some special form of boat, to lie very close to the water's edge, should be devised, and thus be concealed as much as possible from the enemy. But after this little was done by the North with torpedoes, except for the purpose of removing river obstructions, although many inventions were made to cover the necessary conditions.

A mine vessel, the first used since 1809, was a feature of this memorable war. It was devised by General Butler, then in command of the land forces in the vicinity of Fort Fisher, and was intended to destroy this work. Although the Navy Department did not place much confidence in General Butler's plan, they supplied one vessel and the necessary powder. This vessel, the former blockade runner Louisiana, was charged with thirty-six thousand pounds of powder packed in bags and barrels, each containing fifty pounds. Fuses were distributed throughout this immense charge, and connected by quick match, so as to effect a nearly simultaneous explosion at all points. Over one of the central fuses was placed vertically a copper tube with a heavy iron ball suspended at the top, and so connected with clockwork mechanism as to fall on the fulminate below at the end of one hour. The vessel was taken up to the close vicinity of Fort Fisher during the night of December 23 and 24, 1864, the clockwork was set in motion, and the vessel left to perform her work. In order to make sure of an explosion in case the fuses did not work, a fire was started in the bow before she was abandoned. The explosion took place in one hour and twenty minutes, and whether from the fuses or fire is not known. Certain it is, however, that no harm was done. This is attributable to any one of three causes: 1st, the vessel was not nearer than four hundred yards to the work; 2d, if the explosion resulted from the fire in her bow, only a part of the powder could have exploded; and 3d, the arrangement of fuses was such as to render a simultaneous ignition impossible. Experiment proved that an interval of two minutes would elapse between the different fuse explosions. Large masses of powder were seen to ignite in the air. To show the ridiculous effect of this vast undertaking upon the enemy, it is sufficient to quote the telegram sent to Wilmington after the explosion, viz.: "Enemy's gunboat blew up; no effect on the works."

The loss sustained by the union during the rebellion is reported to have been seven monitors and eleven wooden vessels. Many ironclads and wooden vessels were rendered temporarily unserviceable.

It is evident that the terrible effects of submarine mines were shown forth more fully in this great internal conflict than ever before, and the heavy losses sustained by the union fleet attracted the attention of every maritime power and induced strenuous efforts to devise regular systems of torpedo defense. The scruples against the use of submarine mines slowly disappeared, yielding to the necessity of employing them in coast and harbor defense and in naval warfare.

Since the rebellion there have been few or no wars which furnish examples of the use and effectiveness of torpedoes, but most important countries of the world have been and are conducting experiments leading to the adoption of some system considered most effective in case of war.

Among the few examples may be mentioned the submarine mines of the Schleswig-Holstein war of 1864, when the Danes, wishing to oppose the passage of the Prussians into Alsen and Fuenen, had recourse to such weapons. These mines were both electric and mechanical. The Prussians, however, did not make their attack where the mines were planted, and they were therefore of no practical use. The construction of the igniting apparatus in the mechanical mines was curious. Demijohns filled with powder were the torpedoes. Through the cork projected a glass tube into the charge. At the lower end it was bent U-shaped, and in the neck thus formed was placed some naphtha. On this floated three or four potassium pills. The end of the tube in the charge was corked with blotting paper, and around this in a small bag of caoutchouc some mealed powder. The end of the glass tube projecting beyond the cork and outside the demijohn was blown into a bulb. The action of this apparatus was as follows: Upon a vessel breaking the glass bulb, water would enter the tube, force the naphtha against the blotting paper, and being decomposed by the potassium would form oxide of potassium, thus create a flame with the naphtha and set fire to the charge. The whole chemical action is said to be almost instantaneous.

The Germans, however, drove the Danes out of Alsen, carefully fished up the mechanical mines and exploded the electrical ones, thus clearing the way for their navy.

During the war of the Triple Alliance against Paraguay, Marshal President Lopez was finally forced to retreat to territory situated between the rivers Parana and Paraguay. Here his position and the nature of the surrounding country were such that attacks could be made upon him only by a co-operative advance of army and fleet from the south and along these two rivers. To prevent such an advance, he profited by examples set in the American rebellion, and planted submarine mines and obstructions in these rivers. They contained each about one thousand pounds of powder, and had fuses of the Jacobi pattern. The fleet of the Triple Alliance proceeded in September, 1866, to make an attack upon certain fortifications lying south of Asuncion, the capital of Paraguay, so as to effect the capture of the latter place. One of these fortifications, Curuzu by name, withstood for several days the distant bombardment of the fleet, and so a nearer approach was decided upon. The Brazilian ironclad Rio de Janeiro, while approaching a safe anchorage from which to continue a nearer bombardment, struck a large mine. This, exploding, lifted the vessel bodily out of water, and sent up a huge column of spray, hiding her from view. When the water subsided, she was seen sinking. The explosion had broken her in two. Unfortunately for the Paraguayans, their success with submarine mines ended with this fatal explosion. It is not known why more results did not follow. Here was an opportunity to effect the utmost with submarine mines and obstructions, since the enemy's advance was practically confined to the Parana and Paraguay rivers. Had an effective system of mines been used, the tide of battle might have turned in favor of the Paraguayans, but they showed little skill in their use of these weapons.

During the Austrian-Prussian-Italian war of 1866,

Austria had reason to fear that, because of the small size of her navy, her shores would be attacked. Reports of the effectiveness of submarine mines used in our rebellion caused her to turn her attention to the use of these weapons. Consequently, it was decided to defend by them Venice, Pola, Lissa, Gravoso, and Cattaro. Sixteen mines had been planted in front of Venice, when a change of government in that province, and an armistice, followed soon by peace, made it unnecessary to continue the defense, so that Pola and Lissa alone remained to be protected. In this war is the first mention of a plan of co-operation of the navy with the system of submarine mines and land defenses for the protection of a harbor, and this very plan caused some change in the construction of submarine mines necessary. Simple mechanical mines could not be used, as they would prevent a fleet from maneuvering among them. Hence, attention must be given to the electrical ones. Those fired by judgment—*i. e.*, at the will of the operator on shore—had this difficulty, that observation stations must be established in order that the operator might know when a vessel should be in the dangerous zone of any particular mine, and in a large harbor like that of Venice it was not practicable to erect such stations. Judgment mines, it may be stated, as a general rule, should be used only in harbors where the entrance is so narrow as to render observations on the position of a vessel easily, accurately, and quickly taken. Under these circumstances, it became necessary, in the defense of Venice, that some device should be made which would render the action of the mines automatic—*i. e.*, that an enemy's vessel, on striking the mine, should cause the electric circuit to close, and thus work her own destruction.

Baron Ebner, Colonel of the Austrian Corps of Engineers, invented the first circuit closer. Should friendly vessels pass among the mines, the operator on shore could switch the electric current off and render the mines inactive, even though struck. Ebner's mines were cylindrical and made of sheet iron. They contained one hundred pounds of powder. Nine buffers, projecting out of the upper part of the torpedo, communicated the shock of a striking vessel, by means of a connecting rod, to a horizontal cog wheel fixed to a vertical axis passing through the torpedo. The axis carried the electric fuse, which was placed water tight in the charge. The turning of the cog wheel brought the fuse into metallic connection with the cable. By a special arrangement the completion of this circuit caused the change from a simple voltaic current to an extra current of high tension, necessary to fire the fuse, and the voltaic current at the same time caused an electro-magnet at the home station to release a drop number, thereby indicating the particular torpedo struck. The explosion of a torpedo was shown by the deflection of a galvanometer needle. While friendly vessels were among the mines the electric current was, of course, switched off, and if a torpedo should be struck, the circuit-closing mechanism, acting with springs, would, after the blow, resume its original position, ready for action again. Theoretically and experimentally, these circuit closers worked very well, but the mechanism was not such that it could withstand the repeated shocks of friendly vessels and regain its readiness for action. At night the Austrians employed a large Bengal light, in order to detect any small boats of the enemy attempting to cut the electric cables.

With these mines the two harbors of Pola and Lissa were defended. An attack by the Italians on Lissa was repelled by the Austrians on July 18 and no explosions occurred A second attack was not made, so that the mines never came into actual use, which might have shown forth Ebner's system more fully.

With this war closes the history of the actual use of torpedoes in the defense of harbors. For the rest there remains to treat of the results of experiments and investigations which have led to the adoption of torpedo systems by various countries.

To trace out at length the various experiments made would occupy more space and time than are either available or necessary. The general questions for consideration were: 1, The selection of the most effective explosive to be used in subaqueous operations; 2, the size of charge necessary to rupture or destroy either an ironclad or a wooden vessel; 3, the best kind of envelope to contain the charge; 4, the kind of fuse to be employed and the number of points of ignition necessary in a certain mass of explosive substance to produce the maximum effect; 5, the kind of cables to be used; 6, the disposition of the mines with reference to the general plan of the harbor to be defended, and with reference to each other; 7, the selection of operating and testing apparatus and of the operating station.

Investigations made to determine the most satisfactory solution of the points just mentioned have been very elaborately carried out in many countries, foremost among which stand the United States, England, and Norway and Sweden.

With regard to explosives, it has been determined that one should be selected which, when fired, causes sudden action, like a quick, sharp blow, as is the case with dynamite and guncotton, rather than a slower and more pressure-like action which results from the explosion of gunpowder. Hence, explosive compounds are more effective for the work than explosive mixtures.

The size of the charge varies in different countries with the size of the torpedoes. The thinnest envelopes are best for subaqueous explosions, in order that the whole force may be expended in rupturing the vessel rather than that some should be lost in breaking the envelope. On the other hand, the envelope must be strong enough to withstand the constant pressure of water, as also any accidental blows from friendly vessels passing through the line of mines.

As a general rule, most countries use what is termed a platinum fuse for igniting the charge, and which is exploded by a voltaic current. Guncotton and fulminate of mercury are the ordinary priming substances.

Submarine cables are, at present, best made in England, and she supplies many countries, including our own.

In this country dynamite No. 1 is used as the explosive charge; in England, guncotton; in France and Spain, both guncotton and gunpowder; and in Holland, Austria, and Russia, guncotton. Since 1880, however, down to which time information has been published in regard to the use of explosives for submarine mines by different countries, there have been further experiments, and the recent introduction of explosive gelatine, which has an intensity of action under water of 142 per cent. as compared with dynamite No. 1, taken as 100 per cent., tends to make the former worthy of serious consideration as to its use in subaqueous operations of the future.

It may be said that electrical mines have almost entirely superseded the mechanical, although some countries still make use of the latter in the defense of harbors which would only give refuge to hostile navies by affording them a safe anchorage.

For a system of electrical mines, then, there are necessary: An operating station placed in a sheltered position, good submarine cables carefully laid and protected, where they emerge from the water, from the enemy's fire, electrical apparatus, and instruments to determine from time to time the condition of the mines, and all other accessories necessary for the work in view. According to the depth of the water the mines should be buoyant or ground, and circumstances will decide whether they are to be electro-automatic, judgment, or electro-mechanical.

In conclusion will be given briefly a few points taken from different torpedo systems.

England uses electric torpedoes—guncotton is the charge. The Matthieson circuit closer is employed.

The torpedo cases are of steel or wrought iron for buoyant and cast iron for ground mines. Their shape is spherical generally, although in some older models it is different. One is cylindrical, constructed of boiler iron, and held together by rivets; another is conical, topped by a hemisphere. The cable is led in at the base through a screw plug and into a can containing the igniting charge, fuses, and circuit closer. Electric lights are used for night work.

France employs both ground and buoyant mines. The former are of cast iron, hemispherical in shape, with projecting toes to catch and hold in the mud. They contain 2,500 kilogrammes of powder. They employ a separate cable for each mine instead of having a group for one cable. It is claimed for this that, should there be any defect in one of the torpedoes, its cable could be cut out and no other mines would be affected; whereas, should there be a group of mines on each cable, and one should fail, the rest of the mines would be useless. France prefers the simple automatic mine, but makes use of judgment mines in places where correct observations on the position of a hostile vessel can easily be made. The buoyant mine of the French consists of a cylindrical case of wrought iron with an exterior covering of wood. The charge varies from forty-five to fifty kilogrammes of wet compressed guncotton. The electrical arrangement within is so constructed as to admit of either automatic or judgment firing. These buoyant mines are joined to their anchors by a mooring rope of abaca. For electro-mechanical mines, the same cases are used as for the automatic, but the battery supplying the current is placed within the torpedo. It consists of six elements, and is connected with the circuit closer, so that the impact of a vessel will cause the explosion of the mine.

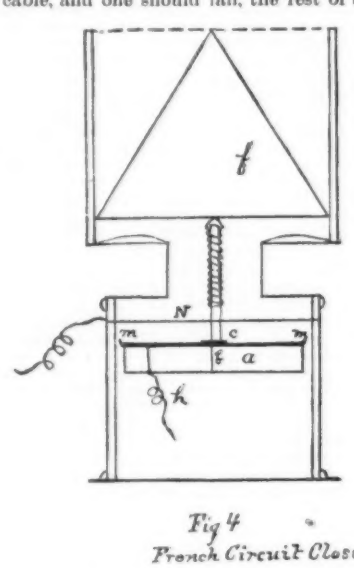


Fig 4
French Circuit Closer

The circuit closer used by the French (Fig. 4) consists of a disk of ebonite, *a*, through which a screw, *b*, with its head countersunk in a metallic ring, *c*, is passed. The ring has its upper surface covered with platinum, and is held to the ebonite by screws with countersunk heads. The ring has also four ears, *m*, *m*, which are 0·003 meter from the lower base of the cylinder, N, when the apparatus is in a state of rest.

Through the center of the ebonite disk passes a brass rod, terminating at its upper end in a small weight of conical form. Around this rod is coiled a spiral spring, which presses up against the base of the cone, tending to raise it. This is prevented by a large weight, *f*, also conical in form, 0·1 meter high, with a base slightly smaller than the diameter of the cylinder in which it acts. When a vessel strikes the torpedo, the large cone tips, the spring forces up the brass rod, and with it the ebonite disk and its rings and ears; these touch the base of the cylinder, N, and close the following circuit: battery to fuse, fuse to screw, through conductor, *h*, thence to metallic ring, through its ears to N, thence to the torpedo case, sea, and home earth plate. When judgment firing takes place, the French use two observation stations, each supplied with telescopes for determining the bearings of the mines.

Holland has adopted the Matthieson circuit closer of the English.

Her mines are judgment and automatic. The general shape of the case is that of an inverted cone with bulging sides, and capable of containing a charge of from forty-five to fifty kilogrammes of compressed guncotton. For judgment firing, a camera obscura is used to cast the reflection of the harbor on a map designating the position of the mines.

Spain, because of the considerable extent of her seacoast and the small size of her navy, has given considerable attention to submarine mining. Her system seems to be made up, principally, from a combination of parts used by other countries. As an explosive, she proposes to take gunpowder, compressed guncotton, and explosive gelatine. The fuse depends on the nature of the explosive and the class of mine. For the mechanical the Abel chemical fuse, and for all electrical mines the Abel platinum fuse, are considered best. For small ground mines they propose the same form used by the French, making the cases of steel, however, and lining them with cork. For larger ground mines the form is the same, but the case is to be made of triple sheets of steel alternating with layers of cork.

The adopted form of the Dutch buoyant mine—*i. e.*, an inverted cone with bulging sides—is proposed for use by the Spaniards, when small charges are to be employed. For larger charges the form is to be conical, while the chamber to contain the explosive will be cylindrical. As in the others, the case is to be made of steel plates, with a jacket of cork. Simple mechanical mines will be made of beer kegs etc., while the electro-mechanical will have the same form as the buoyant and ground mines, and will contain a small battery and the Matthieson circuit closer. Electric cables having seven cores will be used, and at the end of each core one mine. Leclanche batteries for firing and silver chloride for testing will form a part of the operating apparatus. For judgment firing the Spaniards prefer to use the camera obscura.

In the above brief descriptions I have endeavored to give an idea of the principles governing the selection of various torpedo systems, and only so far as relates to the defensive organization which falls within the sphere of land forces. The offensive organization is properly under the control of the naval forces, and I have not touched upon it to any considerable extent.

There is a class of mines known as fish torpedoes, whose functions are offensive-defensive. They are movable, and intended for use in connection with a system of stationary mines. Their object is to attack a vessel which seems to be successfully passing the lines of defensive mines. Such are the Lay, Whitehead, and Simms. When used in naval warfare, they come properly under the offensive class.

Each and every country is governed by considerations affecting the extent of sea coast, number of harbors and importance of same, when adopting a torpedo system, and while each nation which has paid attention to these matters considers its own system best under existing circumstances, yet actual practical results can only obtain from their use in war, whereby existing defects, as yet unforeseen, can be corrected, and the importance of this branch of warfare more fully established.

The secrecy which governs in torpedo systems, and especially our own, does not allow the fullest information to be obtained, and but little is known as to what has been adopted by countries other than those I have mentioned.

COLLODIO-CHLORIDE POSITIVE PRINTING PAPER.

By Dr. S. C. PASSAVANT.

THE advantage of this paper over the ordinary silver paper is that it is from five to six times more rapid, is more brilliant, and very readily toned to any desirable color. Any suitable paper of a firm texture can be used, but it is preferable to employ special Saxe or line plain photographic paper, or, instead, chalk paper used for Lichtdruck purposes. The paper is first coated with a weak solution of gelatine and water, five grains of gelatine to each ounce of water, and then dried. It is next coated with a sensitized collodion emulsion made after the formula devised by F. W. Goldmacher, and described in the *Photographic Times* as follows: "The preparation of this chloride of silver emulsion demands, in the first place, chemicals of the utmost purity and a strict observance of the order in which the different compounds are made. A two per cent. collodion will answer if the coating of the plate is proceeded with slowly. With three per cent. of cotton and the addition of one-half per cent. of castor oil, the film is stronger and more tenacious.

Ordinary plain collodion sold by dealers in photographic materials will answer, but should be diluted with ether to the proportions above stated.

Three separate solutions are now prepared as follows:

No. 1

Nitrate of silver..	20 grammes	(308 grains).
Water.....	20 c. cm.	(5 drachms).
Alcohol.....	50 "	(12½ "

If, with the addition of the alcohol, a recrystallization of the nitrate of silver should take place, the whole mixture must be placed in a warm water bath to be kept in solution.

No. 2.

Citric acid.....	5 grammes	(77 grains).
Alcohol.....	70 c. cm.	(2¼ ounces).

No. 3.

Chloride of strontium..	5 grammes	(77 grains).
Alcohol	70 c. cm.	(2¼ ounces).

Besides the chloride of strontium, other chlorides may answer as well. Chloride of calcium causes higher sensitiveness, but collodion prepared with it prints violet, while strontium proofs are more of a reddish tone, which allows a more correct observation in the subsequent toning process. A reddish tone allows us to see more distinctly the action of the gold bath. The citric acid solution (No. 2) is mixed with chloride solution (No. 3) and the whole added to 800 c. cm. (25 fluid ounces) of plain collodion. This chlorated collodion can now be sensitized by adding the silver solution (No. 1) very gradually and by frequent agitation. To be done by a subdued light (gas or lamp light). The emulsion should be filtered through a thin layer of cotton, after standing a few hours. But as the chloride of silver is held in suspension the bottle should be vigorously shaken just before filtering, in order that the particles of silver may pass through. Shaking the bottle prior to coating is also necessary.

The paper is stretched on a board and clamped by a light frame around the edges. The collodion is then poured on near one corner, and by giving the board a

series of movements with the hand the collodion gradually flows over the entire surface (similar to the coating of a glass plate with collodion), while the surplus is drained off at the opposite corner into a separate bottle. A special hole or niche should be provided in the lower corner of the frame to allow the collodion to easily flow off.

It is also better to use a thin collodion and recoat the paper two or three times, running off the collodion of subsequent coatings at the opposite corner from that of the previous coating, which tends to produce a very even film. Paper coated very heavily is apt to roll up in the water in a very objectionable manner, and will crack when drying. By bending the edges of a sheet of paper over a glass plate, the paper can be very readily coated. It is also advisable to add additional alcohol and ether occasionally to the collodion, to replace that evaporated by frequent lifting of the stopper.

The paper must be dried in a well ventilated room. Dampness is very injurious. Quickly dried paper is also more sensitive and prints with more brilliancy. It is preferable to cut the paper with a dull pair of scissors than with a knife, as there is less danger of injuring the film.

The prints should be washed before toning sufficiently to take off the surplus silver.

A sulphocyanide of ammonia gold bath without the addition of hyposulphite of soda answers the best for toning, and the latter operation proceeds very smoothly, provided the paper is not too old. If kept longer than a week, it is liable to tone very irregular.

A great variety of tones can be obtained, from a pronounced red to a distinct blue, according to the length of time the print is kept in the bath.

Goldmacher advises the following proportions for a

TONING BATH.

Gold Solution.

Chloride of gold..... 1 grain.
Water..... 200 c. cm. (6 ounces).

Sulphocyanide Solution.

Sulphocyanide of ammonium..... 10 to 20 grains.
Water..... 500 c. cm. (15⅓ ounces).

The gold solution is now added to the above, when a red precipitate will occur, which, however, redissolves in a few days. When perfectly clear, the solution is ripe and ready for use. Fifty c. cm. (1½ ounces) of it put into five parts of water will tone one sheet of 18×22 paper. If the sulphocyanide solution is made strong, the tones will be warmer; if weak, then they will become more violet or blue. An old bath used several times produces fine sepia tones.

After toning, the print is slightly rinsed, and is then immersed for ten minutes in an alkaline fresh

FIXING BATH.

Hyposulphite of soda..... 1 ounce.
Water..... 30 ounces.

The bath may be made alkaline by the addition of a little ammonia.

After fixing, the prints should be washed for three hours in several changes of water.

Owing to the delicate character of the collodion film and its liability to be defaced, it is necessary that the greatest care be exercised in the manipulation of the paper.

Liesegang has suggested the application of this collodion film to wood, porcelain, etc., in the following manner: First, a sheet of smooth gummed commercial paper is flowed with the emulsion, as previously described, the print is made, but not toned and fixed. It is then transferred from the paper to any desired support. The wood, porcelain, etc., on which the print is to be transferred is previously coated with a thin film of gelatine. The print—in a wet condition—is now squeeged on to the porcelain, or other support, and the whole soaked in water at the ordinary temperature for five minutes, or until the gum coating between the collodion film and paper softens sufficiently to allow the paper to be easily pulled off. We then have a transparent film left on the porcelain. The picture is toned, fixed, and washed on its new support in the usual manner.

A reversed position will be given to the picture, but this will be of no consequence when it is used as a transparency or a lantern slide.

[NOTE.—Specimen prints of a very beautiful character, made by the above process, have been sent to us by Dr Passavant.—EDS.]

IMPROVED WINE PRESS.

MR. EUGENE MASSON has devised a continuous wine press, which may be used also for making cider, and which we illustrate herewith. In this apparatus, the system ordinarily used is replaced by cylinders. In this way a pressure can be obtained ten times greater than with a screw press, and the pressure is exerted upon a mass of pulp one-quarter of an inch thick without crushing the seeds. The apparatus consists of the following parts: (1) Of a cast iron frame mounted upon four supports; (2) of two compressing cylinders revolving in opposite directions and containing a certain number of apertures to allow of the flow of the juice; (3) of two tin-plated receivers beneath the cylinders; (4) of two hair cloth belts meeting between the perforated cylinders, and between which the material to be pressed is inserted; (5) of four wooden rollers serving as guides to the hair cloth; (6) of two circular brushes serving to free the hair cloth belts of such residue as might adhere to them; (7) of two levers that act through two pistons against the axle of the compressing cylinder, and at the extremity of which are placed counterpoises to exert the desired pressure; (8) of a vertical iron shaft, to which are fixed a bevel wheel that transmits motion to a wheel adjusted to the axle of one of the cylinders and a double socket that receives the wooden lever to which the horse is harnessed; (9) of a hopper over the cylinders for the reception of the fruit; (10) of two tin-plated gutters fixed beneath the hair cloth, and serving to receive the very small quantity of juice that might trickle from the edges of it; and (11) finally, of a collecting pipe that receives all the juice and leads it to the reservoir.

It takes but two men to work the press. The duty of one of these is to bring a certain quantity of grape pulp or rasped apples to the table at the side of the machine, and keep the supply up, and to carry away the residua that falls to the ground or into any sort of receptacle. It is the duty of the other man to pour the material into the hopper, and always to keep a certain quantity of it over the cylinders.

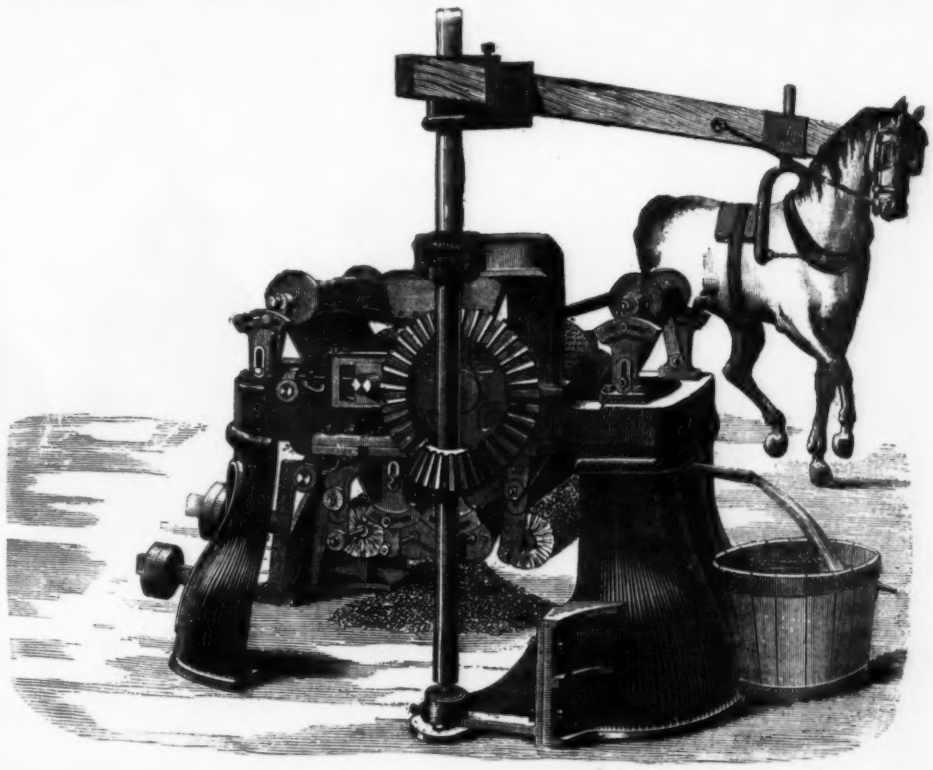
The material is carried along by the two cylinders, and, in passing over their line of contact, receives a pressure more than sufficient to exhaust it perfectly. This pressure may be carried as high as 150 kilos. per square centimeter.

The residuum detaches itself from the hair cloth on coming from the cylinders and falls continuously in a stratum of the width of the belt, and the juice flows in a continuous stream through the lateral pipe.

The time that it takes to do the pressing is about the same as that consumed in putting the material into any ordinary press. From this may be obtained some idea of the saving in time effected. Let us add that in most of the presses hitherto employed, as the edges of the material can receive but a feeble pressure, the operator is obliged to cut them with a hatchet in order to place them in the middle—an operation that is repeated several times during the same pressing—and the marc thus cut cannot fail to give a certain bitter taste to the wine. As this operation is avoided in the press under consideration, the wine obtained is of a better quality.—*Chronique Industrielle.*

OPHTHALMOLOGY.

AN introductory lecture at St. Mary's Hospital, London, was delivered by Mr. A. Critchett, Ophthalmic Surgeon to and Lecturer at St. Mary's Hospital. Speaking of the studies in which he himself is chiefly interested, Mr. Critchett said he was old enough to remember the introduction of the ophthalmoscope by that great teacher and thinker Helmholtz, who, he rejoiced to say, yet lives to witness the priceless boon which his discovery has conferred upon the human race. It was difficult for those who are now familiar with its use to conceive the wondering eagerness with which the original workers sought, by the aid of their new weapon, to bring to light those numerous hidden diseases of the eye which had till then been only partially and most imperfectly recognized. Numerous modifications of the instrument have since been introduced, and among the most recent and most useful improvements has been the ingenious adaptation of the electric light to the ophthalmoscope by Mr. Juler. After alluding to the labors of his late father, of the venerated Nestor of English ophthalmic surgery, Sir William Bowman, and of the much lamented Von Graefe, the lecturer reminded his hearers of the colossal work which had been achieved by Prof. Donders, who had opened out a new world for thought and investigation, and had elevated the study of practical optics to the dignity of a science.



IMPROVED WINE AND CIDER PRESS.

SERPENT VENOM.

AN interesting *resume* of an important monograph by Messrs. Mitchell and Reichert on the venom of poisonous serpents, published by the Smithsonian Institution, appears in the *Dublin Journal of Medical Science* (May, p. 443). The authors, in a previous treatise, have pointed out that serpent venoms are not simple in composition, and have suggested that the differences in their power to kill and mode of causing death are due to differences in the quantity and quality of the constituents. It has been found that the solid matter suspended in fresh venom is inert, and that pure cultures of the micrococci constantly found in venom are without effect. The poisonous matter must consequently exist in solution. No alkaloids have been found, but the venoms contain certain proteid substances, to which the poisonous properties are attributed. These proteids are of two classes, globulins and peptones, the relative proportions of, which differ very much in different venoms, the globulins preponderating in the venom of American snakes and the peptones in the cobra venoms. Three kinds of globulin have been separated, one by the addition of water, one by dialysis, and one by the cautious addition of cupric sulphate, and these have been named respectively "water-venom globulin," "dialysis-venom globulin," and "copper-venom globulin."

After the separation of the globulins the residue gives no precipitate on boiling, but still contains the peptones. A comparative study of the physiological action of the venom globulins and peptones showed that the globulins produce swelling and blackening of the parts by infiltration of incoagulable blood, modify the red corpuscles, and produce molecular changes in the capillary walls. They are also powerful depressants of the heart and paralyze the respiratory centers. The peptones are more active in the production of œdema, in the breaking down of the tissues, and in inducing putrefaction and sloughing. These and other distinctions explain the varying pathological changes which are caused according as the globulins or peptones preponderate in the particular kind of venom injected. When snake venom is brought into contact with the mucous membrane of the stomach in the intervals of digestion, sufficient absorption may take place to prove fatal, this being more probable with the diffusible peptones than with the indiffusible globulins, but the influence of the gastric juice is often sufficient to destroy either of them before absorption can take place. The best local antidote for snake venom was found to be potassium permanganate. Bromine and strong alkalies also proved effective. Ferric chloride is useful to combat those venoms which owe their poisonous properties to globulins. But the authors consider it would be idle to search for a chemical antidote to the poison when once it has entered the circulation, because the active principles of the venom are proteid, and any agent acting upon them would also destroy the normal proteids of the blood.

AN ELECTROLYTIC METHOD OF PREPARING METALLIC ALLOYS, ETC.

By H. WARREN, Research Analyst.

THE following method of preparing metallic alloys, such as silicides, bronzes, etc., has lately been satisfactorily wrought by the following process, which differs slightly from the manner in which mercury amalgamates or combines with mostly all other elements, owing to its liquidity. By substituting for the mercury, iron, copper, zinc, etc., these metals may be readily made to combine with the more oxidizable elements, such as silicon, phosphorus, etc., by so arranging the process that the metal employed for forming the alloy, when in a fluid state, is connected with the negative pole of a voltaic series, and in direct contact with the substance containing the element with which it is desired to combine it.

The apparatus employed consists of a deep conical crucible, through the bottom of which is inserted a pointed graphite rod, projecting about an inch within; the remaining portion being protected by passing through an iron tube coated with borax to prevent oxidation when exposed to a furnace heat. The extremity is furnished with a binding screw or clamp, and connected with the negative pole of the batteries employed, the whole arrangement being heated to the melting point of the metal employed to form the alloy by the aid of a small furnace. Taking, for instance, the preparation of silicon bronze: having introduced a sufficient quantity of metallic copper into the crucible, add sufficient potassium silico-fluoride to form when melted a layer about 2 in. in depth. A thick platinum wire is arranged so that its point just touches the surface of the melted silico-fluoride (care being taken that the melted copper remains sufficiently low so as not to come in contact with the positive pole or platinum wire, otherwise the action is of course neutralized and the power of the batteries uselessly exhausted). This wire is connected to the positive pole of two large cells of the ferric chloride battery, when an in-

stantaneous action is at once perceptible; dense white vapors of hydrofluoric acid are at once evolved from the platinum wire, the potassium silico-fluoride becomes entirely decomposed, and the whole of the silicon when in a nascent state unites with the metallic copper to form a brittle silicide, which may be converted at once into silicon bronze by the usual method, according to the percentage of silicon present.

Phosphor and other bronzes may also be readily formed by slight alteration.

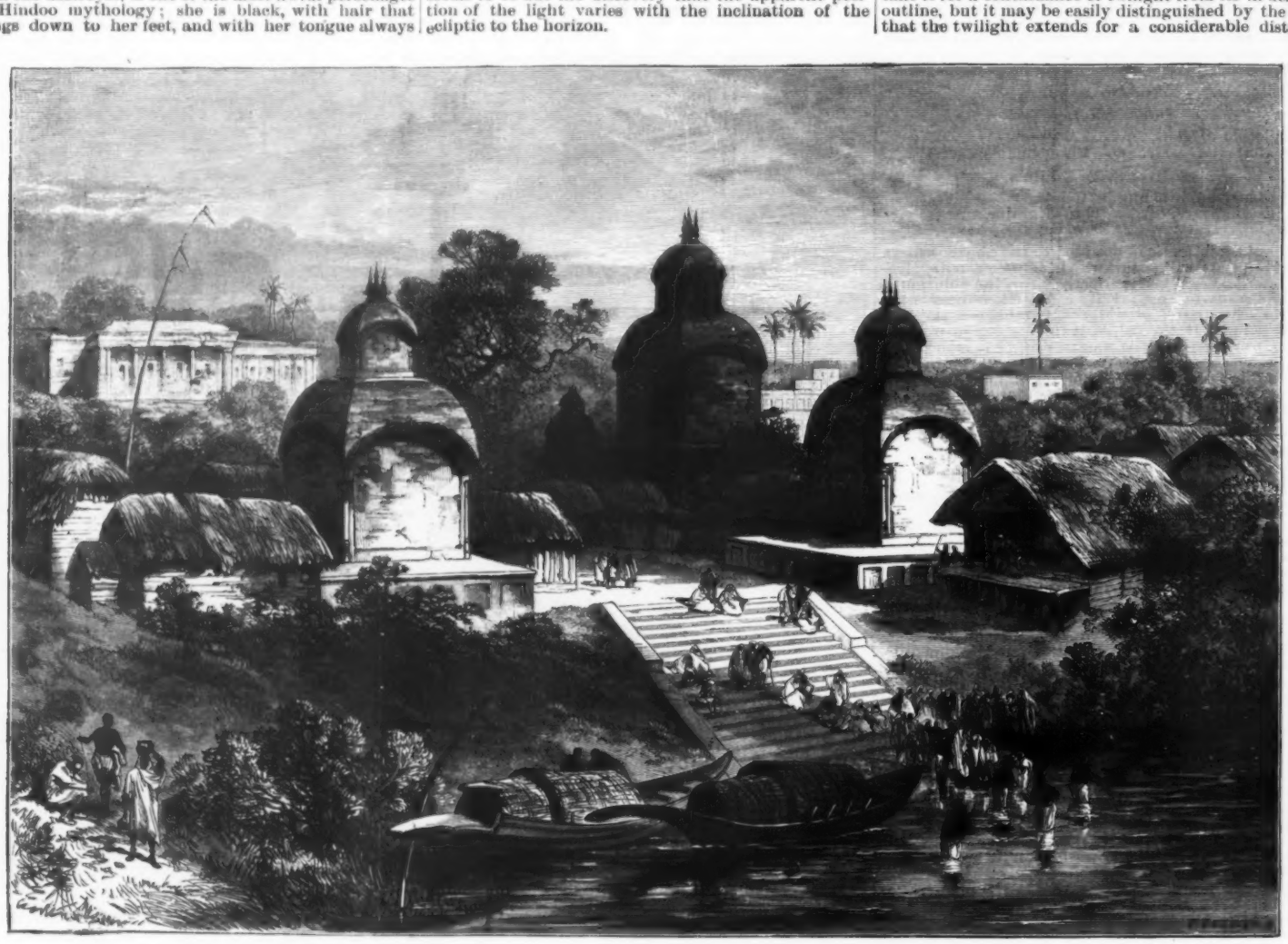
For the preparation of silicon-eisen the substitution of iron in place of copper is all that is required; the silicon-eisen so employed presents the appearance of ordinary hot blast silicide.

Native cryolite may also be readily decomposed when in contact with metallic zinc, and by suitable means the zinc may be volatilized, leaving pure aluminum.

Magnesium, and the earthy metals, barium, strontium, and calcium, have as yet not been satisfactorily obtained as alloys.—*Chem. News.*

THE KALI GHAUT, CALCUTTA.

THE ghauts, or steps to the river, on the banks of the Ganges and Hooghly, at Benares and Calcutta, are conspicuous features of those cities, and give access to the sacred stream for Hindoo rites of purification and sanctification, by which many thousands of religious pilgrims seek to atone for their sins or for those of their deceased parents. The goddess Kali, the wife of Siva the destroyer, is one of the most awful personages in Hindoo mythology; she is black, with hair that hangs down to her feet, and with her tongue always thrust out of her mouth; she has four arms, holding in one hand a cimeter, in the other the head of a giant whom she has killed, while the remaining two hands are stretched forth to welcome her worshipers and to bestow her gifts upon them. This amiable female divinity is adored by the people of Bengal; and her Calcutta temple, on the Kali Ghaut, is much frequented.—*Illustrated London News.*



THE KALI GHAUT, CALCUTTA.

M. EIFFEL.

M. EIFFEL, the projector of the tower of Babel for the Paris exhibition, is no novice in the matter of huge engineering constructions. He made the framework of Bartholdi's "Liberty," and executed the grand vestibule and the principal facade of the Paris exhibition of 1878, a work which came to three million francs. One of his principal works is the bridge which he erected over the Douro at Oporto, on the Lisbon Railway, in 1876, which is, indeed, one of the finest specimens of engineering skill in Europe. The river is spanned by a magnificent arch of 160 meters at a height of 61 meters from the river, and is executed with a view to the artistic effect as well as its stability. This bridge cost a million and a half francs.

Another remarkable work of M. Eiffel is the railway viaduct of Garabit, over the valley of Truyere, in the middle of France, which cost 3,248,000 francs. Here the opening of the arch is 165 meters, and the height above the water 124 meters. He has also constructed some railway bridges and viaducts remarkable for their length, such as a bridge at Szeged, in Hungary, which is 606 meters long, and one at Vianna, in Portugal, which is 736 meters.—*The Architect.*

THE ZODIACAL LIGHT.

By J. E. GORE, F.R. A.S., Honorary Associate and Vice-President of the Liverpool Astronomical Society.

THE zodiacal light is a cone-shaped, or lenticular, beam of light, which makes its appearance at certain times of the year above the eastern horizon in the mornings before dawn, and above the western horizon after sunset in the evening, remaining visible long after twilight has ceased. The phenomenon requires no instruments for its observation, and may best be seen with the naked eye.

The light is generally assumed to be due to a sort of nebulous envelope surrounding the sun, extending beyond the earth's orbit, and consisting of finely divided matter of some sort, which shines either by reflected sunlight or by inherent light of its own due to electrical or chemical action. The hypothesis that it is a terrestrial appendage, and not a solar one, has been shown by Proctor to be inconsistent with its appearance and position as seen in northern latitudes.

There have been numerous observations of the zodiacal light recorded by experienced observers, but it has been remarked by Schmidt that all the observations in the years 1855 to 1868 seem to add little or nothing to our knowledge of the position and true character of this mysterious phenomenon. The first regular observations seem to have been made by Commander Jones, in the years 1853-1855, while engaged on the United States Japan expedition, and to this able observer seems to be due the discovery that the apparent position of the light varies with the inclination of the ecliptic to the horizon.

The zodiacal cone, as it may be termed—to distinguish it from other allied phenomena, which have been called the zodiacal band and the Gegenschein—is, according to Lewis, the only part of the phenomenon which varies in appearance. It has often been described in popular works on astronomy, but is frequently misrepresented, especially in pictures intended to represent its appearance, but which generally show it much brighter and more clearly defined than it is usually seen, at least in northern latitudes. The brightness of the zodiacal light depends upon the time of year. It is most visible when the ecliptic makes the greatest angle with the horizon, and is, therefore, best seen by an observer in these latitudes in the evenings, from the middle of February to the middle of March, and in the mornings about October. As beginners often find a difficulty in perceiving the zodiacal light from not knowing what to look for and when to look for it, observations may be most suitably made at the above-mentioned periods of the year. A clear evening or morning should be chosen, with the moon absent, although feeble moonlight does not overpower it. The last rays of twilight must have died away in the evening, or the observation must be made before the commencement of the dawn, if the inexperienced eye is to detect it as a distinct object. Its appearance then is that of a spindle-shaped light rising from the horizon, and at a steep inclination to that plane. Its light is always brightest near the center, and fades away very gradually toward the edges. According to Lewis, the axis of greatest brightness lies south of the axis of symmetry. The lower edge of the cone is generally more distinctly defined than the upper. Jones found that the light was deficient on the south side when seen from a place north of the ecliptic, and on the north side when seen from the south. This may be explained by atmospheric absorption acting more efficiently in reducing the light on the side of the cone nearest to the horizon. The zodiacal cone is brightest near the sun, but still sufficiently bright at a distance of 50° or 60° from him to be quite conspicuous to a trained eye. The apex of the light occasionally reaches to a distance of 100° from the sun. In the brightest visible part of it, it is several times as bright as the brightest part of the Milky Way visible in northern latitudes. On two occasions—February 12, 1877, and February 21, 1879—it was found by Lewis sufficiently bright to cast a shadow! On the latter night snow covered the ground, on which distinct shadows were visible. In the tropics, where the twilight is very short, the light is much brighter, and visible almost every clear night. In Northern India, the present writer has seen it shining with great brilliancy, and not to be overlooked by the most casual observer; and even in the West of Ireland it was very conspicuous in March of the present year. Jones' observations seem to show an elongation of the zodiacal light toward the east as the evening advances; but Searle points out that this apparent extension may be really due to an effect of contrast caused by an increase in the darkness of the sky for a long time after twilight has ended, and possibly also by an increase in the sensitiveness of the observer's eye, which may take place more gradually than is generally supposed.

Many people, on first seeing the phenomenon, mistake it for a continuance of twilight from its ill-defined outline, but it may be easily distinguished by the fact that the twilight extends for a considerable distance along the horizon, and only reaches up a short distance in the sky, whereas the zodiacal light, at the periods of the year named, makes an angle of about 60° with the horizon in our latitude, and is comparatively narrow.

As has been said, the zodiacal light extends beyond the earth's orbit, and should therefore be visible round the whole sky. Many observers have noticed an extension of this sort, forming a zone of faint light, considerably fainter than the zodiacal cone itself, and which has been called the zodiacal band. This band has been observed by Backhouse, Brorsen, Lewis, and Schmidt; but Searle thinks that his own observations indicate it to be a sidereal and not a zodiacal phenomenon at all. Backhouse can alway see it, under fairly favorable atmospheric conditions, stretching right across the sky, except from about the Pleiades to Præsepe, where it is merged in the light of the Milky Way.

He finds that it cannot be clearly observed when at all near the horizon, as the light of the sky increases downward, and so extinguishes the dark space that would otherwise be visible below the zodiacal band. He can never see it in the southern portion of the zodiac, owing to its low latitude in the north of England. It would seem that keen sight is necessary to observe this very faint band, as, according to Lewis, it is one of the faintest objects in the heavens, being considerably fainter than the faintest portion of the Milky Way. Lewis, who has seen it well, finds that his sight is sufficiently acute to enable him to frequently see twelve stars in the Pleiades with the naked eye. He finds that the band is somewhat brighter in the center than at the edges. It cannot, of course, be seen where it crosses the Milky Way, and is best observed when the

Milky Way is on, or near, the horizon. As might be expected, this faint band of light disappears on moonlight nights, although its visibility in the presence of the moon has, it is said, been recorded on two or three occasions! Although the zodiacal band, on the whole, becomes fainter as its observed distance from the sun increases, yet in the region directly opposite to the sun its brightness revives again to a considerable degree. This brighter region was named by Brorsen, who discovered it, the Gegenschein (in English, the counter glow).

The Gegenschein is always found to lie within 2° or 3° of a point in the heavens 180° from the sun. It is brighter than the zodiacal band, although always much fainter than any of the brighter parts of the Milky Way. The brighter portion of this patch of light is probably circular, and about 7° in diameter, though it has occasionally been observed as apparently elliptical, with the longer axis parallel to the ecliptic. It was independently discovered by Backhouse in 1875, and again in 1883 by Barnard, who found a faint illumination of the sky in that part of the zodiac which is on the meridian at midnight. Observations by Searle—1878-1884—show a marked tendency to place the Gegenschein in north latitude. This result is confirmed by Lewis, who finds that it always lies about 2° north of the ecliptic, not a single observation placing it south of that line. Heis also agrees in fixing its position north of the ecliptic. Searle thinks the fact may be accounted for by atmospheric absorption, but the absence of any observations in the southern hemisphere renders it difficult to decide this point. It is not easy to frame any hypothesis which will satisfactorily account for the appearance of the Gegenschein, but on the meteoric theory it could be explained by assuming such a law for the phases of the meteors that their brightness would rapidly increase as they approached opposition.

The zodiacal light—like all faint, indefinite objects—is seen very differently by different people, as it requires practice to enable its fainter portions to be observed, and eyes vary greatly in power. In order to see it satisfactorily, it will be necessary to exclude all bright light from the eyes, and it cannot be well seen in a town where there is smoke illumined by gas light, or where the electric light is used, as in the city of Boston (U. S. A.), where Searle finds it no longer possible to make any useful observations.

Owing to the fact that the brightest portion of the light is seen only near the horizon, and that most of it is very faint, its appearance is greatly affected by atmospheric conditions. For this reason it is not easy to determine whether its light is variable or constant. Backhouse states that he has never noticed any changes of brightness, other than can be accounted for by atmospheric variations. He thinks it probable, however, that the Gegenschein varies in form and size.

Photometric comparisons of the light with that of the Milky Way will perhaps be necessary to determine whether it really varies in brightness or dimensions. Some observers have noticed momentary flashings in it; but probably these are merely subjective phenomena, similar to stellar scintillation.

The real nature of its substance still remains a mystery. Practically, it is a feeble extension of the solar corona, although probably existing under very different conditions to that portion of the corona visible in total eclipses of the sun. Searle suggests that a portion at least of its light may be due to sunlight reflected from very minute planets which may possibly accompany the asteroids in large numbers; and if we suppose a number of meteoric particles diffused through the solar system and reflecting light irregularly, it may be shown mathematically that an appearance resembling the zodiacal light, with an indefinite vertex, would be the result. Sir John Herschel held a similar opinion. Observations show that the axis is not precisely on the ecliptic. Backhouse, from his own observations, finds the probable position of the ascending node somewhere about longitude 35°, with an inclination of about 1·7°. Houzeau found, from a discussion of 58 observations by various observers, that the longitude of the ascending node is about 2°, with an inclination of about 4°; but owing to the difficulty of making sufficiently delicate observations, it can hardly perhaps be considered proved that there is any fixed inclination. To determine this accurately, observations in the southern hemisphere, and, still better, near the equator, would be necessary, as the atmospheric absorption toward the horizon will necessarily shift the axis more or less toward the north, as seen in northern latitudes.

Cassini was of opinion that the axis of the zodiacal light lies in the plane of the sun's equator, and this idea is partly supported by observation. It also seems probable on theoretical grounds, "for it is possible that the rotation of the sun indicates the fundamental plane of the solar system, if we accept the ordinary nebular hypothesis for its formation, more correctly than can be done by the revolution of the known planets" (Searle).

It was stated by Angstrom that he had seen the auroral line in the spectrum of the zodiacal light, but it is now considered more probable that there was some feeble auroral light in the sky at the time of his observation, which he did not notice, other observers having failed to detect any line. During the aurora of May 2, 1877, the zodiacal light was also visible, and Lewis found that the zodiacal cone gave "a faint, short, continuous spectrum, brightest near its least refrangible end." "It was very faint throughout, and could only be seen through a wide slit," too wide to permit the Fraunhofer dark lines to appear. He thinks that his spectroscopic observations point to reflected sunlight as the source of the light of the zodiacal cone. The aurora gave a much longer spectrum, "though of the same pale greenish color."

Searle finds from his own observations that there exists "a faint permanent band of light" about 2° or 3° in width, closely south of Beta and Eta Virginis, nearly parallel to these stars, and reaching as far as Virginis. It appears, however, that there is a slight relative abundance of small stars all along the ecliptic in this region, which may possibly, he thinks, account for the faint band referred to. Whether this applies to the fainter telescopic stars must be left, perhaps, to photography to decide.

Gulmuyden remarks that if we suppose the zodiacal light to bear the same relation to the general meteoric matter of the solar system that the comets of short period bear to the comets in general, there should be some relation between the plane of Jupiter's orbit and that of the zodiacal light, and he remarks that such a coincidence actually exists, for "the most northerly point of Jupiter's orbit has the heliocentric longitude 188°, or with 60° east elongation, 78°; and for matter in the same plane, but nearer to the sun, the approximation to coincidence with 160° is still greater."

Its appearance in tropical regions is thus described by Dr. Chailler, the African explorer: "Then, as if to give a still grander view to the almost enchanting scene, the zodiacal light rose after the sun had set, increasing in brilliancy, of a bright yellow color, and rising in a pyramidal shape high in the sky, often so bright that it overshadowed the brightness of the Milky Way and the rays of the moon, the beautiful yellow light gradually diminishing toward the apex. It cast a gentle radiance on the clouds round it, and sometimes formed almost a ring, but never perfect, having a break near the meridian; at times being reflected in the east with nearly as much brilliancy, if not so much, as in the west, and making me almost imagine a second sunrise. April and May were the months when the light showed itself in its greatest brilliancy. On April 13, 1865, the glow coming from the west was so bright that it totally hid the Milky Way in the principal part of its course. I could only distinguish it above the Sword of Orion; the glow was the brightest below the planet Mars, and the base of the pyramid reached on the south the part of the Milky Way at the foot of the Cross."

The zodiacal light was noticed in England by Childrey, about the year 1660; and that it was a familiar object in Shakespeare's time may perhaps be inferred from the passage in "Romeo and Juliet:"

> "Yon light is not daylight, I know it, I:
> It is some meteor that the sun exhales."

—*Naturalists' Monthly.*

THE MESQUIT BEAN.

AFTER returning toward the end of last August from a journey of over 700 miles in the dry region of Western Texas, where for two years little or no rain had fallen and destitution stared many new settlers in the face; where no green thing in the shape of forage remained, save the mesquit groves, which in some regions covered

MESQUIT BEAN.

thousands of acres, and bore millions of bushels of nutritious beans, which prevent starvation even in man and fatten stock and prairie dogs, I thought readers of the *Rural* would like to learn something of this wonderful fuel and food plant.

The tree (*Prosopis glandulosa*) belongs to the leguminous or bean family, nearly allied to the acacia. It makes a straggling growth, about 10 to 20 feet high, sometimes reaching a height of 40 feet, a grove when seen at a distance resembling an old, dilapidated peach orchard, except in leaf and fruit. The trees bear heavy crops of beans, such as are shown herewith, where *a* shows the pod, *b* the bean as it lies in the pod, *c* the bean in its envelope, *d* the same cut in two, and *e* the bean itself. Some trees produce two to five bushels of the pods, which are greedily eaten by stock for the

sweet nutriment which lies in the beans, not in the seeds, which are so hard and small that animals cannot chew them.

The wood is very hard, heavy, and durable. The roots are enormous for the size of the tops. Both root and trunk make excellent fuel, even for forging in the smithy, when green. Such wood is procured at some expense, as the digging is laborious.

It is sold in the towns of those regions at about $5 per cord of one ton weight. In a few years these trees cover vacant lands with a growth averaging 10 to 15 feet in height, wherever seeds have been scattered by stock or otherwise. The millions of bushels of the pods annually borne in Texas play no small part in the economy of stock growing. No land is so dry, poor, or rich that it will not produce the tree. It grows from the headwaters of the Red River into Mexico. Where the bark is broken, a fine gum resembling gum arabic oozes out in considerable quantities.—*T. V. Munson, Rural New-Yorker.*

LONG-TAILED LADY'S SLIPPERS.

(*Cypripediums.*)

By W. H. GOWER.

A FEW years ago only about twenty species of this genus were in cultivation, but so rapidly have fresh forms been imported, and so readily have they lent themselves to the hybridizer, that in one collection I counted a few days ago nearly 250 named varieties, a striking proof of the popularity of these slipper orchids. The introduced species, which have obtained the name of long-tailed slippers, from the unusual length of their petals, are C. caudatum, its variety roseum, C. longifolium, C. pearcei, C. roezli, C. stonei and its variety platytænium, C. lævigatum, C. robelini, C. wallisi, C. parishi, and C. sanderianum. Hybridizers have worked

LONG-TAILED LADY'S SLIPPER.
(*Cypripedium caudatum*)

largely with these long-tailed kinds, and many very ornamental forms have resulted from their labors. It may be of interest, therefore, to many of your readers to enumerate the kinds which have emanated from this particular section of the genus, commencing with

C. caudatum.—This remarkable plant was originally introduced from the mountain regions of Peru, where it is said to inhabit boggy places, but under cultivation it appears to enjoy strong heat, or at least the warm end of an intermediate house. It has somewhat erect, ligulate, light, shining green leaves, arranged in a two-ranked fashion (distichous). The scape is erect, and bears from two to three flowers; the dorsal sepal, as also the connate lower sepals, are broad, nearly 6 inches long, tawny yellow, streaked with brown; the petals are narrow, lengthened out into tail-like appendages, reaching to a length of some 2 feet or 3 feet. I have never grown them, however, much over 2 feet, although I have been frequently assured that they do attain to 30 inches and 36 inches in length. These tail-like appendages are nearly of the same color as that of the sepals, but become darker toward the tips, and are not fully developed until several days after the flower opens. The slipper-like lip is oblong, yellowish white, tinged with green and streaked with brown. In the variety roseum it is beautifully suffused with a dark rose color. The flowers open during the months of April and May, and if kept from damp, last several weeks in perfection. C. caudatum has been crossed with other species, and has produced

C. Schrœderæ, which was named in honor of Baroness Schrœder, originated in the establishment of the Messrs. Veitch, of Chelsea, and is the result of a cross between C. caudatum and C. sedeni, the latter a Veitchian hybrid. The result has been to shorten the petals and infuse a greater amount of color into the whole flower. Its habit of growth resembles that of C. sedeni; the sepals are soft reddish green, streaked with greenish purple: the petals are broad and pendent, some 4 inches in length, greenish white suffused with purplish crimson; the large lip retains the form of that of C. caudatum, and is of a dull crimson hue. The plant is robust and vigorous in constitution, and produces its blooms in midwinter.—*The Garden.*

THE CHEMICAL BASIS OF PLANT FORMS.[1]

By HELEN C. DE S. ABBOTT.

THE boundary between the mineral and vegetable kingdom is not a definite line. The individual of the one encroaches upon the dominion of the other. The terms "non-living" and "living matter" are only relatively accurate.[2] "Nature in all its manifestations constitutes a unity," . . . and "all matter is in a sense living."

Through chemical evolution a condition of matter obtains favorable for functional activity or life. This state may be described "as a colloidal albuminoid united with more or less water."[3] Its simplest expression is found in the low forms of plants, slime mould for example. This colloidal basis of life is protoplasm, a chemical compound of complex constitution, very unstable, and manifesting when alive certain properties called vital or "biotic."[4]

Active chemical changes are inseparably associated with both living and dead protoplasm. Synthetical or progressive processes prevail in life, analytical or retrogressive in death.

Absorption, metabolism, excretion, reproduction, contractility, automatism, and irritability are the properties of living matter; disorganization and dissociation, those of dead matter.

Chemists have to discover the subtile differences between the chemical equation of living and dead protoplasm.

I wish to speak of some of the chemical compounds of plants, or more properly the chemical forms, since the structure of all plants is built up of chemical constituents. This subject is as extensive as the genera and species of the vegetable kingdom.

Last August,[5] I read a paper on certain chemical constituents of plants considered in relation to their morphology and evolution. The facts cited tended to show a chemical progression in plants, and a mutual dependence between chemical constituents and change of form.

Among the conclusions reached were the following:

(1.) A similarity of one or more chemical constituents is to be found in all plants which are equally developed, and on the same evolutionary plane.

(2.) The evolution of chemical constituents follows parallel lines with the evolutionary course of plant forms, the one being intimately connected with the other, and consequently chemical constituents are indicative of the height of the scale of progression, and are essentially appropriate for a basis of botanical classification; in other words, the theory of evolution in plant life is best illustrated by the chemical constituents of vegetable forms.

Chemistry will aid us to comprehend the laws of evolution controlling plant forms. Evolution should also apply to chemical compounds as well as to morphology, since the latter can be shown to depend upon chemistry in general.

We have no certain knowledge of the precise chemical changes which take place in transforming carbon, hydrogen, oxygen, nitrogen, sulphur, and other elements into the starches and proteids. We know, however, certainly the necessary conditions of many of these changes. The law controlling the absolute relation or the connective link between the form of a plant and its chemical composition is undetermined. But investigations in plant chemistry have not been conducted with this end in view. The facts which I have to offer to sustain the theory of a possible relation between plant forms and chemical compounds may seem to some inadequate, but no other explanation than the one offered to account for these statements has been suggested.

The chemical composition of the cell contents and wall has been determined in many plants; also of their roots, leaves, flowers, and fruits.

Most of the ash constituents essential or injurious to the growth and development of plants are known, and also the variations in growth caused by the presence or absence of certain inorganic compounds.

The chemical changes through which many plants pass from the germination of their seed to maturity and decay are also known, each separate stage of growth showing a distinct chemical composition or a predominance of some one chemical compound.

It should be especially noted that some chemical compounds occur in certain species of plants and do not occur in others. Certain classes of compounds are found widely distributed through the plant kingdom, accompanied by correlated morphological characters. Some one compound, as saponin, will be found with similar botanical characters in plants of distinct genera and families, on the same plane of evolution or development.

It cannot be the result of accident that chinchona and related plants contain quinine; and other plants distributed through the vegetable kingdom their own typical compounds. Nor can it be the result of accident or changes produced by climate or other causes that an absence of some one or more compounds is accompanied by a modification of the exterior of the plant.

Before taking up the consideration of the above statements in detail, it may be well to study briefly two properties[6] of living protoplasm, namely, absorption and metabolism.

The seeds of plants are the storehouses of a certain amount of latent energy or life, elaborated by the parent plant and stored up in the form of complex chemical compounds. Under suitable conditions of warmth and moisture, certain chemical changes take place within the seed. The latent energy becomes active, and the seedling grows, feeding upon its food supply until it has exhausted its store.

At this stage the little plant must seek from without its food, from the atmosphere and the soil. The soil is of varying and complex composition, containing between its particles gases and moisture. The air which surrounds the leaves of land plants is a mixture of nitrogen and oxygen with small quantities of carbon dioxide, ammonia, varying quantities of aqueous vapor, and occasionally traces of nitric acid.

The elements from these media are absorbed by different parts of the plant, and there is a difference in the manner of absorption by fungi, parasites, air plants, and green plants. However, the elements which are absolutely essential for the nutrition and maintenance of the life of all plants are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, magnesium, iron in the case of green plants, and in certain cases chlorine.

It is characteristic of plants that they must absorb their food in the fluid form. The absorbent organs of plants are the roots for water and salts in solution, and the leaves for gases. In the lower plants, where there are no roots nor leaves, water or substances in solution and gases are absorbed, either directly by the cells of the thallus or by root hairs. Among the higher plants, the root hairs and the uneuticularized epidermal cells of the younger roots are active in absorbing material from the soil.

Any part of the plant, if immersed in water, will absorb a smaller or a larger quantity of it; as, for instance, cut flowers placed with their cut ends in water will absorb, for a time, sufficient to prevent withering. The absorption of gases in higher plants is by means of the leaves, for it has been found that carbon dioxide is absorbed from the air by those organs which are green and contain chlorophyl; and in experiments where the carbon dioxide of the air was cut off from the leaves, though it was supplied to the roots, it was found that the plant could not live long. It has also been found that the presence of carbon dioxide in another part of the plant does not contribute to the formation of starch in the leaves.

Green plants obtain their carbon from the carbon dioxide of the air. Plants which do not contain chlorophyl obtain their carbon by the absorption of complex organic substances. Green plants can absorb complex carbon compounds, and it has been proved, by direct experiment, that they can take up these complex substances when supplied to their roots.

Darwin[1] has shown that the insectivorous plants, by means of their modified leaves, absorb complex compounds, and that these are of importance in their nutrition. Flies and other small insects may often be found clasped in the tentacles of the *Drosera;* and in those experiments small pieces of meat, when placed on the leaves, were dissolved after a time by the secretions of the leaf glands and absorbed.

Hydrogen is absorbed by all plants in combination in the form of water or ammonia and its compounds, or in the complex substances mentioned above.

Oxygen is taken up by plants free or in combination in water or in salts. The free oxygen is especially concerned in destructive metabolic processes. The large quantities of this gas absorbed by plants, and especially by fungi, show conclusively its consumption in metabolic processes.

The process known as the respiration of plants is the absorption of oxygen and the exhalation of carbon dioxide.

The researches of Garreau[2] show that two distinct processes are in operation when leaves are exposed to the light. In the one, oxygen is absorbed and carbon dioxide is exhaled; in the other, carbon dioxide is absorbed and oxygen is exhaled. When the leaves are exposed to a very bright sunlight, carbon dioxide is absorbed and oxygen is exhaled, and the activity of these processes is so much greater than the absorption of oxygen and the exhalation of carbon dioxide, that it appears as if the former only were in operation.

Gases, like solids, can only be assimilated in solution, and as they are soluble in water, the cell walls of submerged plants may absorb them, and the sap near the surface of land plants will dissolve the gases from the atmosphere. The sap of plants contains in solution carbon dioxide, oxygen, and also a certain amount of free nitrogen. That this nitrogen does not enter into the metabolism of the plant seems completely decided by the experiments[3] of Lawes, Gilbert, and Pugh; but the more recent experiments of Atwater[4] and Hellriegel[5] should be compared in this connection, and the matter cannot be said to be definitely settled.

I can only enumerate in this connection, without going into the subject, the possible sources[6] of the nitrogen supply:

1. Organic nitrogenous matter.
2. The ammonia of the air and of the ocean.
3. The nitrous and nitric compounds formed by combustion and by electric discharges.
4. Nitrogen fixed in the soil by microbes.
5. The free nitrogen of the atmosphere.
6. Mineral nitrates.

The sap which is continually flowing through living plants is a watery fluid, holding in solution mineral matters, gases, and organic substances. The root hairs of plants penetrate the particles of soil and absorb the moisture from a film which surrounds each particle, known as hygroscopic water. In thallophytes, the absorption is effected by the cells of the thallus, and in orchids a membrane invests the air roots especially adapted for the purpose. The distribution of water takes place, at least to some extent as its absorption, it passes by osmosis from cell to cell, as it passes originally from without into the superficial cells of the plant. The direction of this movement is not necessarily constant. The proportion of water in each cell varies, and the tendency to establish a fluid equilibrium will cause a current toward those tissues which are deficient. These statements apply equally to gases and other substances held in solution, which are needed for the continuance of the chemical and physical changes going on in the living cells of different parts of the plant.

The changes are more active for different substances in different parts of the plant. The mineral substances

[1] A lecture delivered before the Franklin Institute, January 24, 1887.

[2] Mineral Physiology and Physiography. By T. Sterry Hunt. Boston, 1886, p. 18.

[3] Ibid.

[4] Dr. T. Sterry Hunt.

[5] Chem. Section, Am. Assoc. for the Adv. of Science. Buffalo, 1886. Abstract, *Bot. Gazette*, xi, No. 10, Oct., 1886.

[6] Lectures on the Physiology of Plants. By S. H. Vines. Cambridge, 1886.

[1] Insectivorous Plants.

[2] Ann. d. Sci. Nat., Ser. 3, t. xv.

[3] Phil. Trans., 1860.

[4] *Amer. Chem. Jour.*, viii, Nos. 5 and 6.

[5] *Zeit. d. Ver. f. d. Rubenzucker Industrie*, Nov., 1886.

[6] "The Economical Aspect of Agr. Chemistry." By H. W. Wiley. Proc. A. A. A. S., xxxv, 1886.

absorbed by the roots pass up to the leaves, where they are concerned in the constructive metabolism going on in those organs. The products of these processes pass from the leaves to parts of the plant which are actively growing, and where plastic material is required, or to the seeds or other organs in which organic stores are being laid up.

If the stems or plants are cut in the spring, a flow of sap proceeds from the cut surface of that portion of the stem which is connected with the roots. This fact was investigated by Hales.[1] He concluded that there is "a considerable energy in the root to push up sap in the bleeding season." This force is termed the root pressure, and is the measure of the absorbent activity of the root hairs. The root pressure is not only manifested by causing the flow of sap. It also may cause the exudation of drops of sap on the surface. There is a marked periodicity in the flow of sap, which is not due to the immediate result of variations in external conditions, but is inherent in the absorbent cells themselves.

The current travels from the roots to the leaves through the lignified cell walls of the wood of the plant. The activity of the exhalation of watery vapor from the plant is not the same from their surfaces. The refreshing effect of a shower on withered leaves is due to the moisture penetrating the soil and being absorbed by the root hairs. From experiments[2] it has been shown that if the air is very moist and the leaves dry, the leaf surfaces may absorb a little water.

The cuticle offers a certain amount of resistance to the passage through it of vapor which is due to resinous or waxy substances contained in it. The Mexican *Ocotilla*[3] offers a striking example. It grows in very dry and exposed parts of the country, where rainfalls are infrequent. The bark is chiefly composed of wax and resinous substances.

Other substances, as well as water, can be absorbed by leaves,[4] experiments having shown that if a drop of calcium sulphate solution be placed on a leaf, it will have disappeared in the course of a few hours. This is more rapid when placed on the under surface. Though it seems that leaves may absorb water and substances in solution under certain circumstances, the especial absorptive function of leaves is the absorption of gases, as has been already explained.

The subject of the ash constituents of plants is a very important one in this connection. The essential mineral constituents of plants have already been mentioned. Silicon, fluorine, manganese, sodium, lithium, rubidium, cæsium, barium, aluminum, zinc, copper, titanium, iodine, and bromine have also been found among the ash ingredients of certain plants.

The method of absorption of soluble mineral salts has already been described. A solution of insoluble salts is brought about in a different way. A soil rich in organic matter is always charged with carbon dioxide, and this gas is also given off by the roots of living plants. Water containing this gas is able to dissolve calcium carbonate and some silicates which are insoluble in pure water. The presence of certain soluble salts in the soil brings about a decomposition and renders the insoluble salts more readily soluble. Finally, the insoluble salts are brought into solution by means of the acid sap which saturates the cell wall of the root hair. This acid is not carbonic acid, for its reddening of litmus paper is permanent.

It has been shown by experiment that the chemical elements are not universally absorbed by roots in their combinations in the soil.

The wide differences in the composition of the ashes of plants show that each plant is endowed with a specific absorbent capacity. It is upon this fact that the "rotation of crops" in farming depends. A gramineous plant[5] is able to withdraw relatively larger quantities of silica from the soil than a leguminous plant. The latter can only do so to a very slight extent.

The absorbent capacities of nearly allied species are very different. Again, individuals of the same species yield different ash compositions, depending upon their vigor; and the absorbent capacity of the plant varies at different periods of its life. It has been stated that "similar kinds of plants, and especially the same parts of similar plants, exhibit a close general agreement in the composition of their ashes, while plants which are unlike in their botanical characters are also unlike in the proportions of their fixed ingredients."[6] If an ash constituent can pass through a cell wall, its absorption will take place independently of its use or harmfulness to the plant, but the absorption of essential inorganic constituents will depend upon its relation to the metabolism of the plant.

The ash constituents of a plant increase from the roots upward to the leaves, a fact showing that the leaves are the organs in which more especially active chemical changes take place.

The ash ingredients are usually present in each plant cell; in the cell wall, embedded in the cellulose, and partly in the contents of the cell. The salts of the alkaline metals and of the sulphates and the chlorides of magnesium and calcium occur in the solution of the sap. Silica and phosphates of calcium and magnesium are mostly insoluble, and exist in the tissues of the plant.

Water culture experiments[7] have shown the essential ash ingredients. Potassium, like phosphorus, is always found in relation with living protoplasm. If[8] the plant was not supplied with potassium, it grew very little, and very little starch was formed in the chlorophyl corpuscles of the leaves. On the addition of potassium chloride, the starch grains became more numerous in the leaves, and made their appearance in other parts of the plants. Potassium, doubtless, plays an important role in the formation and the storing up of carbohydrates, for the organs in which these processes are active, as the leaves, seeds, and tubers, are found to be the richest in this element.

It has been observed that cæsium[9] and rubidium can replace potassium in the food of certain fungi (mould, yeast, and bacteria).

Salm-Horstmar describes[1] some experiments, from which he infers that minute traces of lithium and fluorine are indispensable to the fruiting of barley. The same investigator has concluded that a trace of titanic acid is a necessary ingredient of plants.

Zinc[2] is also a frequent constituent of plants growing about zinc mines. Certain marked varieties of plants are peculiar to, and appear to have been developed by, such soils, as the violet, var. calaminarias, and pennycress. In the leaves of the latter plants thirteen per cent. of zinc oxide was found; in other plants from 0·3 per cent. to 3·3 per cent.

From the investigations of Baumann,[3] insoluble zinc salts in the soil are harmless to plants. All plants excepting the coniferæ speedily die in a solution containing 10 mg. zinc to the liter, though traces of zinc in solution are harmless.

The specific action of zinc on the vegetable organism consists in a destruction of the chlorophyl coloring matter and a consequent stoppage of the whole process of assimilation.

Experiments[4] on maize, oats, buckwheat, show that arsenic attacks the protoplasm of the cell and destroys the power of osmose by the roots.

Sulphates occur in the cell sap of organs where chemical changes are rapidly taking place, and are doubtless formed in connection with the decomposition of proteids. Phosphorus occurs in actively growing cells in the most various plants. It has been found present in the green coloring matter of the leaves, and is always found in relation with living protoplasm. Schumacher[5] holds that the chief work of the alkaline phosphates is the acceleration of the diffusion of these difficultly diffusible albuminoids.

Calcium is especially abundant in the leaves of green trees, and it cannot be replaced in the food of green leaves by any other metal. It can be replaced by strontium,[6] barium, or magnesium in the food of certain fungi. Magnesium[7] resembles lime in many points, but is present in larger quantity in the stem and grain, and not in the leaves of the maize plant.

Iron is found to be essential to green plants only. If a seedling be cultivated by water culture in a fluid containing no iron, the leaves will become pale until at length they are nearly white; but on the addition of a small quantity of iron to the solution, or if the white leaves are painted with a dilute iron solution, they will very shortly become green. It plays an important part in the formation of the green coloring matter, though it does not enter into its chemical composition.

"Buckwheat,[8] barley, and oats do not flourish when grown in solutions containing no chlorides, and as in these plants the chlorophyl corpuscles become overfilled with starch grains, it was thought that this element was of importance in connection with the translocation of carbohydrates."

Sodium[9] has been used in water culture to replace potassium, but the plants deprived of potash did not develop.

Manganese is abundant in the ash of *Trapa natans*. I also found it in the different portions of *Yucca angustifolia*.[10]

Iodine and bromine are found in marine *Algæ* and in minute quantity in some plants grown far from the sea.

Silica is found in the form of soluble or insoluble silicic acid. It occurs principally in the cell wall, but it has been found in the cell sap of a plant (*Equisetum hiemale*),[11] and certain cells in the pseudo bulbs of epiphytic orchids[12] contain each a plate of silica.

Experiments have shown that the absorption of silicic[13] acid greatly assists the assimilation of other plant foods, and that plants to which it is supplied show a decidedly more healthy development of grain and straw than others not so treated. Silica is doubtless of mechanical use, giving firmness and rigidity to plant tissues; though the real cause of "laying" of crops has been found to be due to the imperfect development of the tissue, and not to an insufficient supply of silica.

The percentage of ash constituents in plants varies, but the quantity is sufficient to be a very important factor in the consideration of chemical forms of plants.

I have already said that the albuminous cell contents, called protoplasm, are always present in the living cells of plants. The introduction into the cell of the gases, water, and inorganic substances goes to the direct formation of this colloidal body, or assists in it.

It has been stated that the soil, water, and atmosphere supply the food of all plants. It would be of interest to dwell upon the processes of assimilation, and the chemical changes that go on within the living plant, if our time would allow. It may be mentioned that nowhere in any department of chemistry have our former views been more modified than in the physiological chemistry of the vegetable cell during the last three years.

For example, I may say that at least in some plants nascent starch passes in a soluble form from cell to cell by osmosis without conversion into sugar, as was formerly held.

Sugar in some plants may be regarded as a waste product, resulting from the breaking down of more complex substances, of no further service in the development of the plant.

Sorghum[14] cane, at the time of the maturing of the seed and the full growth of the plant, contains the largest percentage of sugar, and this sugar appears to be really a waste product.

The classification[1] *of Plastic and Waste Products*, in Vines' late *Physiology*, cannot be accepted as final, since many changes in plant chemistry have resulted since 1882—the date of his chemical bibliography.

It may be generally said that the proteids or albuminoid substances are formed in the cell from a simple carbohydrate and some nitrogenous body, probably an amide.

The inorganic acids supply sulphur and other substances necessary to enter into combination with the proteid, or act mechanically by removing waste material.

The function of chlorophyl may be briefly stated.[2] It absorbs certain rays of light, and thus enables the protoplasm of the cell to avail itself of the radiant energy of the sun's rays for the construction of organic substances from carbon dioxide and water.

Plants which are grown in the dark, or at low temperature, are usually of a yellow color. Such plants are said to be etiolated. There is reason to think that this yellow substance, etiolin, is an intermediate substance in the formation of chlorophyl, for if it is exposed to light it is converted into a green color. These complex coloring matters are probably derivatives of protoplasm.

The autumnal change of leaves is owing to a third coloring matter, called xanthophyl. In many cases, the leaves also contain a red coloring matter, erythrophyl.

The importance of chlorophyl in the plant will be admitted when it is said that the absorption of carbon dioxide, the evolution of oxygen, and the formation of many organic substances are effected solely by chlorophyl corpuscles.

The organic acids occur in plants free and also in combination with bases. It is to the presence of these bodies that the acid reaction of plant tissues is due. Some organic acids are assimilated by plants; the turgidity of cells is to be ascribed to their presence, and the acid sap in root hairs renders possible the solution and absorption of mineral substances insoluble in water.

The primary function of the resins[3] of coniferæ and analogous juices of other plants is to render service in cases of injury, and, by covering the wound with a protecting coating, to favor its healing.

During my studies on the Yucca,[4] resins and saponin were separated from each part of the plant. Experiments were made to determine the emulsive power of saponin on resins. It was found that aqueous solutions of saponin were able to emulsify many classes of resins, and in my paper it was pointed out that saponin may serve mechanical purposes in the plant as well as those of nutrition.

(To be continued.)

ANALYSIS OF CIDER OR APPLE VINEGAR.

By B. F. DAVENPORT.

THE following detailed practical method of determining whether a sample of "cider vinegar or apple vinegar" conforms to the requirements of the Massachusetts statute relating thereto, which requires that it should be not only the legitimate and exclusive product of pure apple juice or cider, but also that it should not fall below the quality of possessing an acidity equivalent to the presence of not less than 4½ per cent. by weight of absolute, that is monohydrated, acetic acid, and should yield upon full evaporation at the temperature of boiling water not less than 2 per cent. by weight of cider vinegar solids, may prove of interest to those dealing in the article.

As the limits set by the statute are in per cents. by weight, the portion of vinegar taken for the tests should, for perfect accuracy, be also taken by weight. That is, the quantities of 6 and of 10 grammes are to be taken for the tests of strength and of residue; but as taking it by measure, if of about the ordinary atmospheric temperature of 60° to 70° F., will make the apparent percentage at most only 1 to 2 per cent. of itself greater than the true, that is, will make a true 5 per cent. vinegar appear to be, say, from 5·05 to 5·10 per cent., measuring proves in practice to be accurate enough for all common commercial purposes, and therefore the quantities of 6 and of 10 cubic centimeters by measure may be taken in place of as many grammes.

It is most convenient to have the measuring burette of a size to contain 25 to 50 c. c., that is cubic centimeters, and have these divided into tenths. The best form of burette is the Mohr's, which is closed by a glass stopcock. Besides this only a dropping tube, called a pipette, graduated to deliver 6 and 10 c. c., will be needed.

The only two chemicals needed in determining the strength of a vinegar are a 1 per cent. solution of phenolphthalein in diluted alcohol and a sufficient quantity of the volumetric solution of soda.

Having these, the procedure for making the test will be as follows: Fill the pipette by suction and then quickly close the top of it with the forefinger. Raise the tube out of the sample of vinegar and let it empty out by drops exactly down to the top graduation mark, this bearing the mark of 0 c. c. Then holding it over a white mug or cup, let it run out exactly down to the 6 c. c. mark. Dilute the 6 c. c. of vinegar, thus measured out into the mug, with sufficient clean water to make it look about white, and then add to it about three drops of the phenolphthalein solution.

Then having prepared the burette by filling it up to the top, zero, or any other noted mark of the graduation, with the volumetric solution of soda, let the soda solution run out cautiously into the diluted vinegar, which should be constantly stirred about. As soon as the vinegar in the mug begins to darken, the soda should then only be allowed to run into it by drops. This dropping is thus continued until at last a final drop of soda turns the vinegar suddenly to a permanent pink or cherry color, which will not disappear upon further stirring. By now reading off from the graduations of the burette the number of full c. c. divisions and of tenths which have been emptied out to bring about this change of color in the vinegar, is known the

---

[1] Statical Essays, 1, 1769 (4th edition).

[2] Detmer and Boussingault.

[3] H. C. De S. Abbott, Proc. A. A. A. S., xxxiii (Am. Journal Pharm., Feb., 1885).

[4] Boussingault: Ann. Chem. et Phys., ser. V, xiii; also, Agronomie, VI, 1878. Mayer: Landwirthschaftl. Versuchs-Stat., xvii, 1874.

[5] Wolff: *Aschen Analysen*, 1871.

[6] How Crops Grow. By S. W. Johnson. London, p. 145.

[7] Nobbe, Siegert, Wolff, Stohmann, Sachs, and others.

[8] Nobbe: Die organische Leistung des Kaliums, 1871.

[9] Naegeli: Sitzber. d. Akad. d. Wiss. zu Munchen, 1880.

[1] *Jour. fur Prakt. Chem.*, 1884, p. 140.

[2] A. Braun and Risse (Sachs: Exp. Physiologie, 153).

[3] Landw. Versuchs-Stat., xxxi, 1-53 (*Jour. Chem. Soc.*, 1884, p. 1408).

[4] F. Nobbe and others. Landw. Versuchs Stat., xxx, 381-422. (*Jour. Chem. Soc.*, 1884, p. 1409).

[5] Physik der Pflanze, p. 198.

[6] Naegeli.

[7] R. Hornberger and E. V. Raumer; Bied. Centr. Bl., 1882, 837-844 (*Jour. Chem. Soc.*, 1883, p. 491).

[8] Vines, Cambridge edition, p. 136. Also, Beyer: *Landw. Versuchs-Stat.*, xi. Leydhecker: ibid., viii.

[9] Salm-Horstmar; Knop and Schreber.

[10] Yucca Angustifolia. Helen C. De S. Abbott, Trans. Am. Philos. Soc., Dec. 18, 1885.

[11] Lange: *Ber. d. deutsch. chem. Ges.*, xi.

[12] Pfitzer: Flora, 1877.

[13] C. Kreuzhage and E. Wolf: *Landw. Versuchs-Stat.*, xxx, 161-198. (Jour. Chem. Soc., 1884, p. 1112.)

[14] H. W. Wiley. *Botanical Gazette*, 1887.

[1] Cambridge edition, 1886.

[2] Cambridge edition, p. 157.

[3] H. De Vries: *Chem. Centr. Bl.*, 3, xiii, 565. (*Jour. Chem. Soc.*, 1883, p. 365.)

[4] Trans. Am. Phil. Soc., Dec., 1885.

per cents. and tenths of acidity equivalent to true acetic acid contained in the vinegar being examined. This, if it is a pure cider vinegar and well made, will be upon the average about 6 per cent., but never under 5 per cent. If in like manner 10 c. c. of the vinegar is exactly measured off by the pipette into a small light porcelain dish, and then evaporated fully to dryness over boiling water, the number of grammes weight gained by the dish, when multiplied by ten, gives the percentage of solid residue contained in the vinegar.

There are certain characteristics peculiar to the residue of a pure cider vinegar, the principal of which are the following: It will be about 3 per cent. in weight, and never less than 2 per cent. It is always soft, viscid, of apple flavor, somewhat acid and astringent in taste. A drop of it taken up in a clean loop of platinum or of iron wire and ignited in a colorless Bunsen gas lamp flame imparts to it the pale lilac color of a pure potash salt, without any yellow due to sodium being visible. The ignited residue left in the loop of wire will be a fusible bead of quite a good size, and it will leave a strong alkaline reaction upon moistened test paper, effervescing briskly when immersed in an acid. The presence in a vinegar of the slightest trace of any free mineral acid will prevent the ignited residue leaving any alkaline reaction, or effervescing with acids. The presence of any practical amount of commercial acetic acid added to "tone up" the strength of the vinegar will cause the igniting residue to impart another color to the Bunsen flame, and the residue itself will have a smoky pyroligneous taste or odor. Any corn glucose used in the vinegar will cause its residue when ignited to emit the characteristic odor of burning corn, and as the last spark glows through the carbonized mass to usually emit the familiar garlic odor of arsenic, for the common oil of vitriol usually used in the production of glucose is now mostly derived from pyrites, which al most always contain arsenic.

A glucose vinegar which has been made without vaporizing the alcohol after the fermentation of the glucose will also have a strong reducing action upon a copper salt in an alkaline solution, and also will give a heavy precipitation of lime with ammonium oxalate. A true malt vinegar always contains phosphates, and a wine vinegar cream of tartar. The presence of any acrid vegetable substance in a vinegar is known by the residue having a pungent taste, especially if before the evaporation the vinegar has been exactly neutralized with soda.

In a pure apple cider vinegar hydrogen sulphide gas will not cause any discoloration, nor will the addition of a solution of either barium nitrate, silver nitrate, or ammonium oxalate cause anything more than the very slightest perceptible turbidity. But the addition of some solution of lead acetate—that is, of sugar of lead—will cause an immediate voluminous and flocculent precipitation, which will all settle out in about ten minutes, leaving a clear fluid above. In most of the so called "apple vinegars" brought into this market from other States the addition of some of this lead solution will cause but a slight turbidity, without any precipitate settling out for several hours, and even then the precipitate will not be of the same appearance as in apple cider vinegar.—*Chem. News.*

MANUFACTURE OF STARCH, DEXTROSE, AND GLUCOSE.

By Prof L. V. WAGNER.

LEON CUISINIER, in Paris, has patented a process for the saccharification of starchy substances by means of a malt which has been allowed to germinate for from 7 to 10 days. The raw materials must be made perfectly neutral (acid free) by treatment with a one per cent. soda or ½ per cent. sulphuric acid solution, as the case may be. The grain after two or three days' soaking in tepid water should contain not more than 40–45 per cent. water, and is then to be ground. The moist materials are made into a paste with an equal weight of water, and from 2½ to five per cent. of malt is well kneaded into it, during an hour. The liquefaction of this paste takes place in an upright cylinder, surrounded by a water bath which is maintained at 75° C., and provided with powerful stirring gear. The mash thus obtained is then heated in a steam jacket, under a pressure of one atmosphere for about an hour, then cooled to 70° and treated with one to two per cent. of malt infusion. After two hours the solution is put through a filter press, cooled to 50°, and treated with fifteen to twenty per cent. of malt infusion, which is added in five per cent. lots every two hours. When thoroughly saccharified, the solution is heated again, filtered, and evaporated to 40° Be., and sold as concentrated beer wort.

Joseph Franklin Gent, of Columbus, Ind., U. S. A., frees maize from the germs and husks by steaming at 160° in a special apparatus, for not longer than one minute, and subsequently crushing and sifting the grain. The product thus obtained is then again steamed, pressed into thin cakes, and brought into the market under the name of "Cerealine."

Messrs. Vierneisel, K. Trolsch, and Alfred Cards recommend the following treatment of potatoes for the purpose of dextrose manufacture, avoiding thereby the necessity for the separation of the starch from the pulp, which always retains a considerable percentage, and utilizing the roots at the period when they contain most starch—viz., at their harvest time; thus avoiding also the loss of starch which stored potatoes always undergo. The potatoes are washed and ground, the paste put through a filter press, in which the cakes are well washed with a solution of calcium bisulphite, to prevent any fermentation, and then either dried for storing or worked up forthwith. The cakes made into a suitable paste with water are saccharified under pressure, by acid. The acid sugar solution is thereupon neutralized with calcic sulphite and chalk, put through a filter press, evaporated to 30° B., again filter-pressed, and finally concentrated at 100° down to 35° B., for crystallization. The resulting sugar when separated from the molasses is ready for the usual processes of recrystallization.

Thadeus v. Korzins Sakovicz and David Rosenblum, of Warsaw, produce crystallized grape sugar from all sorts of starch by boiling ten per cent. solutions of starch with certain quantities of sulphuric anhydride, which quantities vary from 4·9 per cent. with eleven hours' boiling when working in open vessels to 0·15 per cent. when the operation is conducted in a closed vessel and under a pressure of four atmospheres. The boiling in the first case lasts eleven hours, in the latter only four hours. Instead of using charcoal to decolorize the neutral sugar solution, it is cooled to 45° and about 0·2 per cent. (on the weight of starch) of permanganate of potash added, whereby a brown precipitate is formed, the solution after passing through the filter press being perfectly colorless. The crystallization is performed under vacuum, but the crystals cannot be readily freed from the mother liquor.

Alf. Seyberlich, of Riga, and Alex. Trampedach, of Mitau, transform starch into sugar by the action of dilute nitric acid. The starch is made into a milk with water, and run into a dilute boiling solution of nitric acid, and boiled until ten drops of the solution added to 200 c. c. 96 per cent. alcohol no longer produce any turbidity. The proportions used are 1,000 starch, five nitric acid, and 2,000 to 3,000 water. They then recommend that the solution be made distinctly alkaline by the addition of sodium or potassium carbonate, thereupon evaporated in the vacuum apparatus to 35–36° Be., and allowed to crystallize. The crystals thus obtained are well developed, and easily separated from the mother liquor.—*Dingl. Polyt. J.*

CURIOUS PROPERTY OF GAS RETORT CARBON.

A CURIOUS property of the carbon of gas retorts has been brought under the notice of the Academie des Sciences by MM. Debray and Pechard. They observe that when pieces of retort carbon, previously purified by the action of a current of chlorine at a high temperature, are used as electrodes for the decomposition by current of acid solutions, the positive electrode disintegrates more or less quickly, forming a very finely divided black powder. This is a fact well known to experimentalists, but hitherto not explained. Most of those who have noticed the phenomenon, however, have had their attention fixed upon the alterations occurring in the fluids in which the electrodes are immersed than upon these latter.

MM. Debray and Pechard, however, are disposed to think that the disintegration of the carbon is not due to any mechanical action, but to an alteration, more or less profound, of the matter itself, and that the powdery matter produced by the carbon is, in reality, of the nature of an alloy of carbon. It has been found that this pulverulent carbon contains oxygen, water, and even nitrogen, when it has been used in the electrolysis of nitric acid. These various matters were, therefore, united with the carbon under the influence of the electric current. Whatever the electrolytic acid used, this black powder, well washed and dried *in vacuo*, deflagrates when heated in a glass tube just below a red heat. The deflagrated carbon disengages also, under a more lively heat, carbonic oxide and carbonic acid. It is thus evident that carbon in the purest form attainable in commerce—that of retort carbon—is capable of entering directly, under the influence of an electric current, into unsuspected combinations with other elements.

THE SCIENTIFIC AMERICAN Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

MUNN & CO., Publishers,
361 Broadway, New York.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE

Scientific American Supplement.

PUBLISHED WEEKLY

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—The Zodiacal Light.—By J. E. GORE, F.R.A.S.—This mysterious phenomenon described.—The opinion of different observers as to its cause..... 9938

II. BIOGRAPHY.—M. Eiffel.—Note of some of the engineering triumphs of the projector of the great Paris tower..... 9938

III. BOTANY.—Long Tailed Lady's Slippers.—By W. H. GOWER.—A remarkable family of orchids, embracing several hundred varieties.—1 illustration..... 9940
The Mesquit Bean.—The valuable food tree of the Southwest.—Its value in times of drought.—Its peculiarities and characteristics.—1 illustration..... 9939

IV. CHEMISTRY.—Analysis of Cider or Apple Vinegar.—By D. E. DAVENPORT.—The testing of vinegar for acetic acid and general examination for purity..... 9941
Curious Property of Gas Retort Carbon.—An interesting note on the power possessed by carbon of forming solid compounds with other elements directly..... 9941
The Chemical Basis of Plant Forms.—By HELEN C. DE S. ABBOTT.—First installment of a valuable contribution to chemical botany..... 9940

V. ELECTRICITY.—An Electrolytic Method of Preparing Metallic Alloys, etc.—By W. WARREN.—An interesting method of decomposing ores, etc., in the dry way by an electric current..... 9937
A Dining Room Electric Railway.—A electric waiter for supplying dishes at a dinner party.—2 illustrations..... 9937
Electricity as a Motive Power.—By WM. WHARTON, Jr.—An elaborate review of electricity as applied to the propulsion of street cars, with figures of expense and practical details..... 9937
Telegraphing to and from Trains in Motion.—Account of this last achievement in telegraphy, with full illustrations of the apparatus and its application.—4 illustrations..... 9939

VI. ENGINEERING.—Box Car Bodies.—Different types of framing for freight cars described and discussed.—3 illustrations..... 9932
Description of the New Tay Viaduct.—By Mr. F. F. S. KELSEY, resident engineer.—Full account of this great viaduct, the methods of construction, and the character of the completed structure..... 9930
Refrigerating Machinery for the Steamship Fifeshire.—The most powerful refrigerating machinery ever applied to ship work, producing an extremely low temperature by the expansion of compressed air.—3 illustrations..... 9931
The Change of Gauge of Southern Railroads in 1886.—By C. H. HUDSON.—An elaborate account of this great feat in engineering, with details of the treatment of curves, rail couplings, etc.—23 illustrations..... 9936
Tramway Engine.—An improved smoke-consuming tramway locomotive described and illustrated.—3 illustrations..... 9933

VII. MISCELLANEOUS.—The Kali Ghaut, Calcutta.—The steps leading to the Ganges for the use of Hindoo pilgrims.—1 illustration... 9938

VIII. NAVAL ENGINEERING.—History of Submarine Mining.—By SAMUEL RODMAN, Jr., U.S.A.—The second installment of this important paper, bringing the history down to the present day.—1 illustration... 9935

IX. PHOTOGRAPHY.—Collodio-Chloride Positive Printing Paper.—By Dr. S. C. PASSAVANT.—A rapid and brilliant printing paper, with full formulæ and instructions for its use..... 9936

X. PHYSIOLOGY.—Ophthalmology.—The ophthalmoscope and its improvements and uses..... 9937
Serpent Venom.—The effect of the poison of snakes upon the human system..... 9937

XI. TECHNOLOGY.—Improved Wine Press.—A continuous press for wine or cider, driven by horse power.—1 illustration..... 9935
Manufacture of Starch, Dextrose, and Glucose.—By Prof. L. V. WAGNER.—New processes in this branch of technical manufacturing summarized..... 9942

PATENTS.

In connection with the **Scientific American,** Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.